Swinging on a Shad-bush Leaf, waiting for Dusk.

A Sphinx moth (*Smerinthus excaecatus*). The fore wings show blended shades of brown and tan; each hind wing has a large rose-colored patch containing a blue-centered spot of velvety black. Natural size. Photographed from life.

MOTHS AND BUTTERFLIES

BY

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WITH TWO HUNDRED PHOTOGRAPHS FROM LIFE BY THE AUTHOR

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PREFACE

THERE has arisen a need for insect books of an elementary nature, in harmony with the modern work in animal ecology, interpreting habit and detailed structure as responsive adaptations to surroundings, and further interpreting fundamental structures as a sign of blood relationship. With such an aid a student ought not only to gain training in observation and a broad view of the group studied, but should also gradually get hold of the underlying principles of natural science which give the right foundation for natural-history work on other groups.

"Moths and Butterflies" is an outgrowth of the writer's interest, inspired by the enthusiasm shown by children in grammar grades, students in the Rhode Island Normal School, and teachers in summer schools where this subject has been presented.

The subject cannot fail to be interesting for several reasons. It leads into a freer out-of-door life. Nowhere in nature or in art is there more beautiful coloring than in moths and butterflies. Most marvelous changes in form occur during their development, and since they are common everywhere and easily kept in captivity, these changes can be seen without difficulty. They have instincts developed to so high a degree that they do many things for self-preservation which it seems impossible to believe are not the result of self-conscious intelligence. Finally, moths and butterflies, in spite of all their enemies, belong to the group of animals dominant in numbers in the world to-day; this means that here we find most wonderful illustrations of perfect adaptation to environment.

For one who has done no work along this line, moths and butterflies make a most charming recreation study for the

summer months. The subject is full of surprises and discoveries. It reveals the marvelous and beautiful where we had expected only the commonplace. It brings a realization of the adaptation of a creature to its life by the perfection of minute detail. It opens our eyes to the balance of life that exists in all nature. It broadens and deepens our view of the universe.

The book "Moths and Butterflies" is entirely untechnical in its treatment of the subject. It will identify by means of photographs from life forty common forms, in caterpillar, chrysalis or cocoon, and adult stages. It makes clear the external structure adapting the creature to its life; it describes and illustrates the changes in form from caterpillar to chrysalis, from chrysalis to butterfly. It is adapted to give quick insight into the secrets of the group.

For young people natural history is of great educational importance, outside of its pleasure value. Its paramount value lies in the fact that it not only places before the senses a host of opportunities for pleasurable observation of concrete objects, but that it also leads the mind gradually but surely to the power of independent thought and judgment. When a structure, or habit, or condition of environment is seen, the question naturally follows, "How does this help the creature in the circumstances of its life?" or, "How has this structure or this habit ever come about so perfectly to fit the creature to the conditions of its life?" In answering these questions the boy or girl becomes an independent reasoner.

Because of this value — along with other values — natural history has been given a place in the educational system of to-day. But let us remember that natural history loses much of this value when merely talked about or when read from books. From the intellectual standpoint, natural history forfeits a part of its claim to a position beside the other subjects of the curriculum unless it is studied from the living objects themselves, and as far as possible in their natural environments.

Original investigation on the part of each boy or girl, with the delights that come from the discovery of even the simplest facts

and relations, must be the method for this subject. This book will not give its best results unless the last chapter with its questions is made the working chapter, the stories or fragments of stories of Parts I and II being read after the same moths and butterflies or nearly related forms have been studied; the relationship chapter of Part III should be studied after there have been some chances for original work in comparison.

This method applied in grammar grades requires that considerable time be given during a whole year, or during a half year at least, to so large a subject. There will be of necessity some collateral work on the identification of various low-growing plants and of trees, on the structure of spurred and of tubular flowers, on insects other than moths and butterflies, and on the relations of moths and butterflies to agriculture. This is certainly all that can be accomplished in the spring and fall of one year, even adding to the work that can be done in the time allowed the subject in the school some home work on the part of those most interested.

Nature study will never accomplish what it is capable of accomplishing — will never gain the deep, lasting interest of children, will never give any large amount of information, and will never train in scientific method—until the number of topics studied is sacrificed somewhat to thoroughness and inductive method. Observation and interpretation work in any subject whatever to be effective must concentrate attention on one part of the subject for a considerable length of time, excluding during that time other parts of the subject, except in their most pertinent points of relation.

MARY C. DICKERSON.

PROVIDENCE, March, 1901.

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Part I

BUTTERFLIES

He prayeth best, who loveth best,
All things both great and small:
For the dear God who loveth us,
He made and loveth all.

COLERIDGE.

THE MONARCH BUTTERFLY, OR MILK-WEED CATERPILLAR

Fig. 1. — The Monarch. Male. Orange-brown wings with broad black veins and borders; white spots in borders; scent pouch on posterior wing. Natural size. Photographed from life.

THE MONARCH[1]

He who knows the most, he who knows what sweets and virtues are in the ground, the waters, the plants, the heavens, and how to come at these enchantments is the rich and royal man.

EMERSON.

My butterfly net and pocket magnifying glass are rare companions for a walk in the country.

WILLIAM HAMILTON GIBSON.

FROM May until late October we may see the Monarchs flying. We all know them, large butterflies measuring between four and five inches, and conspicuous because of their bright orange-brown and black coloring. They are to be seen in large numbers over low meadows and along roadsides, flying in a quiet, easy way, apparently never in a hurry. They rest so long on red-clover blossoms that we may pick them up in our fingers. They are very common; not only the meadows and roadsides and fields know them, but all the flower gardens welcome them. They add beauty — and they are very beautiful — to the forest, to the mountain, to the seashore. They are everywhere; and what boy has n't caught one under his hat, and held it struggling between his fingers, and rubbed off all the brown dust from the wings?

In the mountainous regions of New Hampshire I have seen them sporting about the tops of the tall pines while a stiff wind was blowing. Monarchs indeed! they are well named. Let us watch one. "It seems fairly to

[1] *Danais archippus* (Dan'a-is ar-chip'pus), or *Anosia plexippus* (A-no'si-a plex-ip'pus).

revel with delight in a gale; now it rolls and tosses and heaves, always heading against the wind; now it spreads its sails to the breeze, and is hurried violently backward and upward; again it furls them, and, slowly descending and advancing, it describes a variety of the most charmingly graceful curves and waves and undulations imaginable; a thing of beauty to look at and a joy to think of forever after." As Mr. Moffatt suggests, "Storm King" would be an appropriate name for this butterfly. I have often thought so when I have seen it sporting in much this same way during a light fall of rain.

If we go to Martha's Vineyard, they are there, sailing high over the brightly colored cliffs at Gay Head. If we go on to No Man's Land, and beyond, we shall have many chances to hail Monarch butterflies. Their power of flight is greater than that of any other butterfly.

The Monarchs are native Americans, but have become very widely distributed, so that now they are known well-nigh all over the world and are likely to become quite cosmopolitan. They belong in tropical America, and it is supposed that our spring Monarchs at the north are migrants from the south, and that in the fall all our Monarchs go south. If this migration of the Monarch is certain, this butterfly is one of most peculiar interest and certainly has what seems to be a most delightful way of spending the winter.

There are many observations on record to prove the southward journey. On the approach of cold weather the butterflies swarm in immense numbers, just as the birds do when getting ready for their migration. There may be thousands of butterflies in a swarm, so that when

they settle down in a field or on trees the prevailing color will be changed to brown.

Supposably, those that do not join the clans and go to a warmer clime are not able to endure the cold and die when the severe weather comes; at least no one has ever discovered a hibernating Monarch in the Northern States.[1]

Observations are not on record to prove the northward journey in the spring. Possibly they move as individuals rather than in large swarms, each butterfly flying long distances north, and still farther north to find food plants for its young.

Before proceeding to the life history of these butterflies, let us look closely at the butterflies themselves (Figs. 1 and 24), with two aims in view: to see their fundamental structure, that we may know their relationship to other creatures, and to see some details of structure, that we may understand their habits and realize how wonderfully they are adapted to the lives they lead; for two points that we must make emphatic in all our nature study are life relationship, shown by fundamental structure, and life habits as related to structure and environment.

There is the long, slender body showing very plainly division into three parts, — head, thorax, and abdomen. Attached to the thorax on the underside are three pairs of jointed legs, the anterior pair undeveloped and inconspicuous.[2] They are used for clinging (Fig. 2) and are poorly adapted for walking. Attached to the upper side

[1] For further reading on their migration, refer to Chap. IV, Scudder's "Life of a Butterfly," Henry Holt & Co.

[2] The Monarch belongs to the Nymphalidæ, the "Four-footed Butterflies."

of the thorax are two pairs of wings. The abdomen is made up of rings or segments.

Looking more closely, we find a pair of antennæ, or feelers, attached to the anterior part of the head and projecting forward when the butterfly is alert. They are thread-like, with small knobs at the ends (Fig. 5). The antennæ are the organs of smell, and it is most amusing to watch their use while the butterfly is feeding. They are constantly thrust forward to touch the flower, one at a time or both together, as if the creature were getting as much pleasure through smelling its food as tasting it, — a state of things that we can easily appreciate.

FIG. 2. — Monarch with folded wings resting on milk-weed. Natural size. Photograph from life.

The wings are very conspicuous and the most attractive feature of the butterfly, giving it motion and beauty. In the Monarch the posterior wings are somewhat smaller than the anterior. All four wings are orange-brown above and below, veined and bordered with broad black.

There are double rows of white spots in the black borders. The males have the wings less broadly bordered with black than the females, and they have a black scent pouch [1] on the upper surface of each posterior wing. When a butterfly is hungry and alights upon a clover, its eagerness and excitement are plainly visible in the wings. They are lifted and lowered again and again; little shiverings and vibrations go through them until the nectar is found, when the wings are folded above the back and all is quiet until the flower cup is empty. Then the butterfly's eagerness is again plainly told by the vibrating wings until another full clover cup is found, when again they are folded above the back.

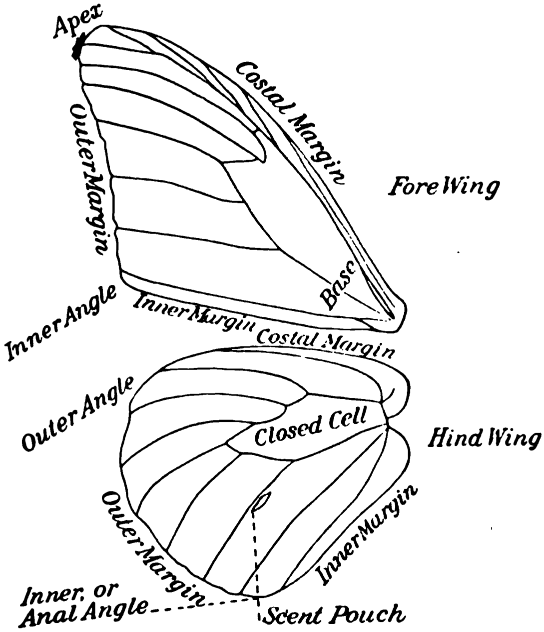


FIG. 3. — Arrangement of veins in the wings of the Monarch.

The wings are always folded in this way when the butterfly is resting, and it is wonderful how like a dead brown leaf the insect then looks from a little distance (Fig. 2). This must serve the purpose of protection,

[1] Read Chap. XII, Scent Scales: a Question of Sexual Selection, Scudder's "Life of a Butterfly."

although the Monarch scarcely needs the safety given by resemblance to its surroundings, for it is said to be extremely nauseous, so that birds never attack it. If a young bird in its inexperience and eagerness for food does attack a Monarch, the experiment is not likely to be repeated.

The wings are thin and transparent and have traversing them many small blood vessels and air tubes, forming the so-called "veins"[1] (Fig. 3). However, they are covered above and below by closely overlapping colored scales.[2] These make the wings strong and also give the beauty of coloring. One fully realizes the beauty and order in the natural world when looking at a series of butterfly wings under a microscope or even a hand-lens. The

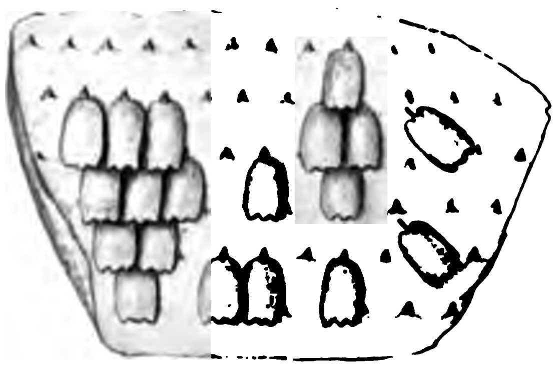


FIG. 4. — Arrangement of scales on fragment of Monarch wing (many have been rubbed off). Greatly enlarged.

scales, each one held in place by a stem fitted into a minute pocket in the chitin, are arranged with the fringed or scalloped free edges of the scales in one row overlapping

[1] Butterflies and moths are classified largely according to the arrangement of veins in the wings.

[2] Therefore the moths and butterflies are called "Lepidoptera," from *lepis*, a scale, and *pteron*, a wing.

the attached ends of the scales of the adjacent row (Fig. 4). They are of all sizes and shapes, in some cases most fantastic in shape, and of course of all colors. Besides the one color which predominates in each scale, there is a most pleasing play of rainbow colors, and it is the combined effect of this iridescence of the scales which gives the marvelous iridescence of the whole wing.

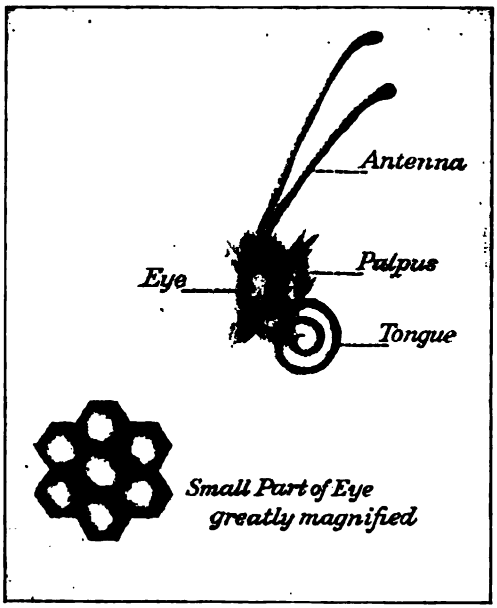


FIG. 5. — Head of Monarch. × 3.

The eyes (Fig. 5) of the live Monarch butterfly are half spheres, gleaming like jewels in the sunlight. They are the typical compound eye of insects, made up of thousands of minute eyes, the hexagonal facets of which are invisible without the aid of a microscope. Insect vision is supposed to be very defective. The Monarch can distinguish light and shadow, in a vague way can see color, and probably moving objects, as one will soon find out when trying to catch butterflies; but its one keen sense is that of smell. It is this sense that guides the butterfly to its mate, to its favorite flowers, and, most wonderful of all, to the plants on which its young can feed.

The Monarch butterfly is well adapted for its life by its power of flight, by its nauseous quality, by its keen sense

of smell located in the antennæ, and by its peculiar proboscis,[1] which enables it to procure its food, the nectar of flowers. The proboscis, or "tongue," is a long, black, hollow tube and is coiled like a small watch spring between the palpi on the underside of the head (Figs. 5 and 25). The palpi protect the "tongue" when it is not in use: in fact they almost hide it from view. But when the antennæ proclaim the fact that food is near, the proboscis is rapidly uncoiled and straightened to its full length: the end is thrust into the honey cup of the flower, and the nectar is pumped up through the long tube into the little creature's stomach. (Refer to Figs. 28 and 63.)

"Idle butterfly," "gay trifler," "the type of the frivolous"! At one time in its life the Monarch belies these common names. It diligently seeks out a milkweed plant, flutters nearer and nearer it, rests a moment on one of its leaves, then flies away. It seeks another milkweed plant, flutters slowly about it, finds a leaf to its liking, rests a moment on it, and is gone. And so it continues. What is the meaning? It may not stop for honey from the milkweed flowers; perhaps the plants are young and have not yet bloomed. If we watch closely, we shall see that while the butterfly is clinging to the edge of the leaf, its abdomen is slowly curved upward and the end is pressed gently for a second against the lower side of the leaf. If we examine the leaf afterwards, we see a small milk-white egg, of sugar-loaf shape, and less than one-twentieth of an inch high, glued securely to the underside of the leaf (Fig. 6). The eggs are laid singly, and usually on the undersides of the upright terminal leaves, but they may be found almost everywhere on the plant, on the small

[1] Read Chap. II, Scudder's "Life of a Butterfly."

flower buds and stems, on the upper surfaces of leaves near the top, and on those lower down on the plant. The egg is very beautiful, but we need a more powerful eye than the human eye to see all its beauty. It has from twenty-one to twenty-three slender ridges radiating from the center of the top and extending to the base, and the spaces between are crossed by many very fine parallel lines at right angles to the ridges. At the apex of the

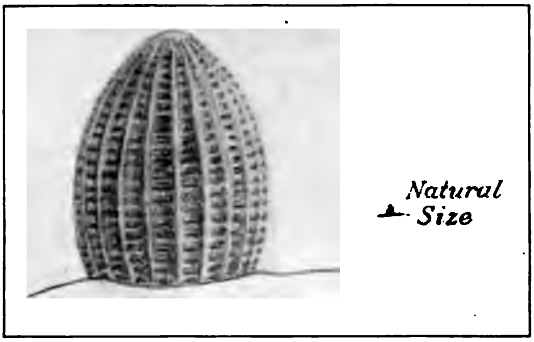


FIG. 6. — Monarch Egg. Greatly magnified.

egg, the center from which the ridges radiate, there is a minute rosette of the most delicate lines.

Many of the instinctive acts of butterflies seem to be performed by the use of intelligence, so nicely are they adapted to the needs of the insect. Of them all the butterfly's choice of a place for its eggs seems most marvelous. The unerring instinct that leads a creature to place its eggs on certain definite plants so that its young may find food in abundance as soon as needed, on plants for which the creature itself has no need, seems truly marvelous. It can see the form of the plant and leaves but indistinctly with its imperfect vision; it cannot even take a bite just to see if it tastes right. It can smell it? Yes,

but how does it know that that is the odor of the plant that the young butterflies (the caterpillars) will like to eat? We can simply fall back on the term "instinct."

William Hamilton Gibson, in his volume "Sharp Eyes," which is full of inspiration for the student of nature, very aptly calls butterflies "botany teachers."[1] The Monarch always chooses some member of the milkweed family on which to deposit its eggs, making one exception in the case of the dogbane. But the dogbane is very nearly related to asclepias; in fact, the older botanists placed it in the same family, because of its silky seeds, its opposite leaves, and milky juice.

The eggs hatch in four or five days unless spiders or crickets have found them. The little caterpillar eats its way out of the egg; at the top it climbs out. The edges of the opening in the top are all jagged, showing the work of the minute jaws. (Refer to Figs. 134 and 157 to see same process in Cecropia and Polyphemus.) The egg-shell is then devoured quite down to the surface of the leaf, probably to tell enemies who may hunt there later that no young caterpillar is anywhere in the vicinity. After eating the shell the tiny atom of life crawls to the inner face of the newest leaf at the top of the plant and there eats the first meal of juicy milkweed, sometimes making a small hole entirely through the leaf.

We can find the small Monarch larvæ on the top of the milkweeds, down amongst the young leaves or on the flower buds, from the first of June until the last of September. The early appearance of faded Monarchs, so that eggs are laid and young caterpillars are out of the egg by the first of June, may point to hibernation rather

[1] "Sharp Eyes," pp. 80-87, by William H. Gibson. Harper & Brothers.

than migration. Who will find a live Monarch in winter?

After about two days of voracious eating, with periods of rest between meals, the caterpillar finds its skin much too tight for it and sheds it. The larva is now large enough to be seen easily, perhaps one-third of an inch long, a rather pretty, aristocratic-looking little fellow — for a caterpillar. The long, slender body is almost perfectly cylindrical, with twelve distinct bands of black encircling it, the black bands being separated by bands of yellow and white. Near the head there are two very short black horns, and there is a still shorter pair near the posterior end. If the caterpillar is disturbed in any way, it quickly spins a thread and drops on it, rolled into a ball, sometimes hanging in mid-air as a spider does, but more often dropping quite to the ground.

For the next five or six days the caterpillar develops very rapidly, moulting the skin twice during this time. It eats greedily day and night, with only short periods of rest spent on the concealed side of some horizontal leaf, midway between the stem and the tip of the leaf, with head outward. Let us look at the almost full-grown caterpillar and see how it is adapted for its life; how it is fitted to move from its feeding grounds to its resting place, to eat the thick milkweed leaves close down to the midribs, to sleep with its weight hanging from the underside of a leaf, and to protect itself against enemies.

The caterpillar (Fig. 7) now is a very conspicuous object, a little less than two inches long, and very distinctly banded with black, yellow, and green. The black horns are long and flexible. The colors of the caterpillar are not protective. They are called "warning" colors, for the

larva has the nauseous quality of the butterfly. This is its chief protection. Hiding is another means of protection. While resting the caterpillar is always on the underside of some horizontal leaf, and we may be certain that it is absolutely motionless. "Lie low" is the watchword in caterpillar world from first to last, and is the main safeguard. The Monarch larva is also protected by its habit of dropping to the ground in a ball when in any way disturbed. If you think this does not protect it, try to find one after it has fallen into the grass. However, now that it is large it seems to have lost the habit of spinning a thread on which to ride down and crawl back, but drops full weight into the grass and weeds (Fig. 8).

FIG. 7. – Milkweed caterpillar, walking from resting place to feeding grounds. Length 2 inches. Banded with black, green, and yellow. Black flexible horns on second and eleventh segments. Slightly enlarged. Photograph from life.

The caterpillar's body is most flexible. It is made up of twelve segments besides the head (Fig. 9). There are three pairs of legs attached to the three segments nearest the head, a pair for each segment. The legs are short,

have small pointed claws at the ends, and, most important of all, they are jointed. In fact, they are the undeveloped butterfly legs, and for this reason are called the "true legs." There are five pairs of legs on the sixth, seventh, eighth, ninth, and twelfth segments, one pair for each segment. These are called "prolegs," or prop-legs, and are of service merely during the caterpillar stage. However, the caterpillar would be very helpless without them; its long, heavy body would be quite unmanageable with only the slender legs near the head. The prolegs (Fig. 10) are not jointed; they are mere extensions of skin and muscle, looking like diminutive elephant's feet. They are wonderfully adapted

FIG. 8. — Monarch larva as it falls into the grass for protection.

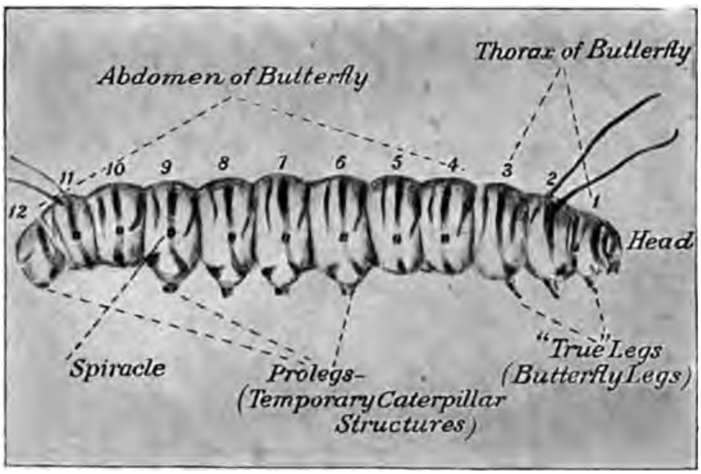


FIG. 9. — Milkweed caterpillar, to show external structure.

for the service they give the caterpillar. They can be drawn in or protruded, lifted and put down again, and when they are put down hundreds of tiny sharp hooks

are exposed on each one. These hooks catch into the hairs and roughnesses of the milkweed leaf and stem, or into the fibers of the silk pathway the caterpillar has spun as it walked, and we can easily understand why the caterpillar is not afraid to walk or rest on the underside of a leaf. And so the Monarch larva moves rather fearlessly about its milkweed home, up and down the stems, out and under the leaves, and it does not need to spin many pathways of silk, for the milkweed has a rich covering of hairs.

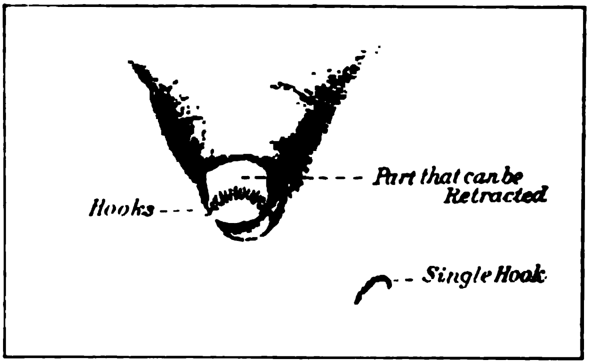


FIG. 10 Inner side of proleg, to show hooks. Greatly magnified.

But put Milkweed larvæ into a glass house with their food at the top and they will have to spin a dense carpet of silk all the way up the sides of the glass. The glass is too smooth; each caterpillar must proceed slowly, spinning silk from the small spinneret (Fig. 11) on the underside of the head, moving the head constantly from side to side, back and forth in a figure 8. The silk is fastened to the glass by the glue exuded with it and so makes a firm foundation for the hooks of the caterpillar's prolegs. It is interesting to note that no caterpillar uses the path prepared by another; each laboriously spins its own carpet on which to walk, and this will be done even after the

glass is so covered everywhere by silk that we can scarcely see through it. The Milkweed caterpillar walks ; it never runs, as do many ; it has the quiet, easy manner of the adult butterfly, probably the result of its secure protection. As it walks, the long black flexible horns are moved alternately forward and backward.

It is very easy to find a Milkweed caterpillar eating, for it spends the greater part of its existence in this way. The mandibles (Fig. 11) are strong, horny jaws at the

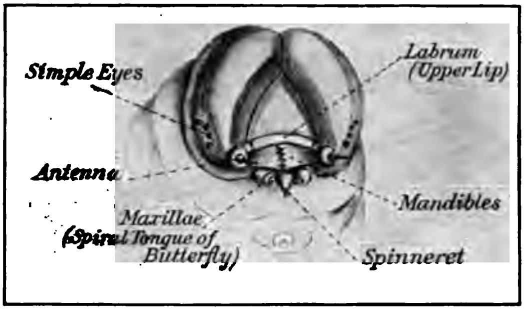


Fig. 11.—Head of Milkweed caterpillar, to show eyes, mandibles, and spinneret. Greatly enlarged.

anterior end of the head and somewhat underneath, working from side to side. From their rapid, effective action it is easy to guess how sharp and strong they are. The caterpillar usually attacks the leaf at its margin and, holding it between the true legs, rapidly cuts it out in overlapping, retreating curves. The true legs act as hands, holding the leaf, and pulling and pushing it into position for the mandibles. (Refer to Fig. 102.)

The caterpillar breathes through spiracles, nine pairs of small openings with valve-like edges. They show plainly on the sides of all segments except the second, third, and twelfth (Fig. 9). They open inside the body

into air tubes (tracheæ), which branch again and again, carrying air to every part of the caterpillar body. This is the same apparatus for breathing that exists in the butterfly.[1]

This caterpillar seems very nicely adapted for its life in its milkweed home. It is out in the broad field where the air is always pure. It can hide under the broad expanse of the lower leaves if the sun is too hot or the rain too heavy; it can always go there to rest or for concealment. The rough, hairy surfaces of the milkweed leaves and stems allow easy progress; or, if there are smooth places, a pathway of silk can easily be spun. Tender, fresh food is always at hand, and so too is the best instrument possible — strong, sharp jaws — for cutting the food into small bits.

FIG. 12. — Eating. Natural size. Photographed from life.

However, the caterpillar is a very helpless creature out of its proper environment. This is largely due to the

[1] The spiracles and tracheæ are lacking in the second and third segments of the butterfly, probably because these segments are taken up by the muscular apparatus for wings and legs. The lack of the breathing apparatus in these segments in the caterpillar may be in preparation for the condition of things in the adult.

fact that it cannot see well. The eyes, simple, shining elevations, so small that they can scarcely be made out with the naked eye, are in a curved row on the sides of the head (Fig. 11). They can do little more than give power to distinguish light from darkness; so, although they serve very well when the caterpillar is in its own house, where every leaf and stem are familiar to it, they fail to do proper service when the caterpillar is cast abroad. It can only walk blindly on and on until it chances upon food again.

The caterpillar whose life we have been studying has lived perhaps eight or nine days, and has passed through three moults. It must pass through one more moult. We can easily tell when it is to take place. The caterpillar stops eating, takes position on some leaf or stem, and spins a thick mat of silk. Forward it goes spinning, with head moving to right and left, until it has covered a space somewhat longer than its body; it then turns around and goes back over the same space, gluing a second layer of silk on top of the first; then it turns around and goes forward once more. Finally it takes position on this mat of silk and rests. Of course the hooks of all the prolegs are entangled in the silk; this is an important factor in the process.

When you have caterpillars in captivity do not push one off its support in giving it fresh food or in examining it until you are sure it is not resting on a carpet of silk; because it cannot spin a second mat of silk, for a very

good reason, which we shall see immediately, and it is almost, if not quite, impossible that it shed its skin without the aid of this carpet. They remain perfectly inactive in this position, looking as though they were almost dead, for at least twenty-four hours. The moulting process usually takes place at some time during the forenoon, a very opportune time for investigation. If we examine the caterpillar just before the moult, we find the colors somewhat dulled and the whole outer skin loosened. The caterpillar is covered by a thin skin of horny matter (chitin) which serves as a protection; but this being made of inorganic substance does not grow nor stretch, and after the caterpillar has eaten much and grown, it is exceedingly uncomfortable in its tight clothes. It must get rid of them.

If we look still more closely at the resting caterpillar, we find it seems to have two heads, one a very light-colored large head, the other a smaller darker one in front. The caterpillar looks as though it had a small black cap drawn far down over its eyes. The fact is, the whole skin has been loosened and slipped forward enough to allow the head to be drawn out of its old skin backwards, so that it shows plainly through the body skin of the first segment. The old head skin is directly over the mouth-parts, and we can easily see that the caterpillar could not respin its carpet of silk. Here is a moulting caterpillar on a milkweed leaf; bend over the leaf so that we may see the new head with the old head skin far down over the mouth-parts (Fig. 13). This forcing of the head into the body skin puts increased strain on the thin chitin, which was already tightly stretched. The result is a splitting where the strain is greatest, in the

skin of the first segment. That the skin was very tight is demonstrated after it is split — by the rapidity with which it shrinks backward with almost no effort on the

FIG. 13. — Ready to moult. Head drawn back into transparent body skin, giving caterpillar appearance of having two heads.

caterpillar's part. It shrinks back over the true legs, and over the horns, which are drawn out of their old skins and lie adhering to the body because of the great amount of moisture. It shrinks over the first pair of prolegs, and over the second; but at this point its taut condition and its rapid drying will carry it no farther, and the caterpillar must begin to make some effort. But usually it is most concerned at this time with the old head skin, which is still over its mouth-parts. The head is rubbed against the support, from side to side, back and forth, as a bird rubs its bill on a branch; the anterior true legs are used vigorously as hands to brush it off; finally it falls. Now all parts are free except at the posterior end; to get rid of the discomfort there, the caterpillar pulls out the remaining prolegs and walks

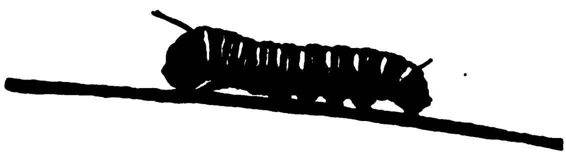


FIG. 14. — Ready to moult. Side view. Photographed from life.

forward, leaving the shriveled skin behind. The hooks of the old prolegs hold securely in the carpet of silk, forming a brace, so that mechanically this moulting of

the posterior part of the caterpillar's skin is a possibility. (Refer to Figs. 103, 104, and 105 to see Promethea in same process.)

The caterpillar is much larger than before the moult, and light colored. In an hour or more the darker colors have returned and the chitin has hardened, so that the caterpillar is ready to pursue its ordinary habits of life, and if we can judge by action it is very glad to break its long fast. But before it attacks the milkweed leaves it eats the thin shriveled skin which is still clinging in the silk carpet, presumably so that its presence will not tell to enemies the nearness of the caterpillar itself.

Of all periods in the Monarch's life this moulting season, which recurs four times before the caterpillar is full-grown, is one of the most critical. During the twenty-four hours or more of the preparation for moulting, the caterpillar is helpless and is protected only by its remaining perfectly still; after the splitting of the skin back of the head the process is a very short one, taking only five minutes or even less; but then follows the hour or more, during which the new skin hardens, before the caterpillar is again equal to the situation.

The Milkweed caterpillar has much the same appearance from first to last, but very often after the third moult the black bands are much broader, occupying the space usually filled by green and black, so that the caterpillar will appear very many shades darker than other Milkweed caterpillars.

After this fourth moult the larva eats greedily for two or three days and then becomes very restless, wanders up and down its food plant, and finally leaves it to seek the shelter of some neighboring fence or stone, or, more likely,

some other green plant. If the caterpillar is in captivity, it may walk ceaselessly for hours and at last seem perfectly exhausted. We may think it sick or dead, and the belief is helped out by the fact that the alimentary canal is thoroughly emptied in preparation for the long sleep as a chrysalis which is to follow. This fact is always a sign that the change to chrysalis is at hand, and that if we wish to see the process and get all the secrets it is time for us to be on the watch. The caterpillar chooses the underside of some horizontal surface and there spins a carpet of silk as it does when about to moult; but the carpet is made very thick in one spot. Then the caterpillar walks over this carpet until the posterior prolegs are over the thick button of silk; there it rests, and of course the many hooks of these prolegs become entangled in the silk. After a short time of rest the caterpillar lets go its support with its true legs and four pairs of prolegs and drops, hanging by the posterior prolegs only. The position looks like a hazardous one, but the caterpillar hangs fearlessly, curving the head and anterior part of the body upward so as almost to touch the point of attachment. This position is maintained for some twenty-four hours. At the close of this time the colors are dulled, the skin seems loosened, the horns are shriveled, and the body is not so greatly curved; and at the posterior

Fig. 15. — In position to moult for chrysalis. Drawn from under-exposed photograph.

end we can look through the transparent skin and see the more slender end of the chrysalis (Fig. 15).

The curved position of the body has put the skin on the dorsal surface near the head under great strain, and it was already under strain because it was much too small for the caterpillar's body, and in addition the mid-line of this dorsal surface is the weakest place in the caterpillar skin. The skin now splits at this weakened place and shrinks slowly upward, carrying the head skin along with it on the ventral side. The chrysalis, or immature butterfly, is slowly revealed as the skin withdraws; it is soft and light green; all the butterfly parts show plainly, the wings wrapped from the back to the front, the antennæ, the legs, and the "tongue" folded down the front close to the body, the segments, and the spiracles. We have time to note all these as they are uncovered by the retreating skin (Fig. 16).

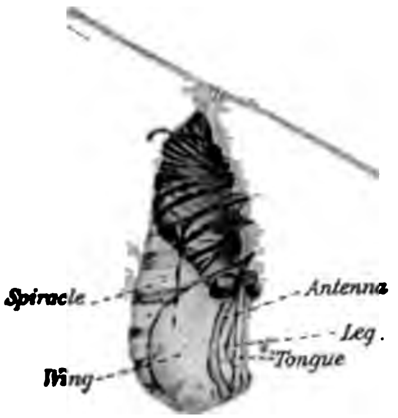


FIG. 16. — Moulting for chrysalis. Drawn from under-exposed photograph.

Now, owing to the original taut condition of the skin and the efforts of the chrysalis, the skin has split so far up the dorsal side and shrunk upward so far that only the posterior end of the chrysalis is covered by it. Now look closely. See what the chrysalis must do! It must remove

the end from the old skin and attach it to the button of silk above and do this without falling. It is usually done quickly and easily.

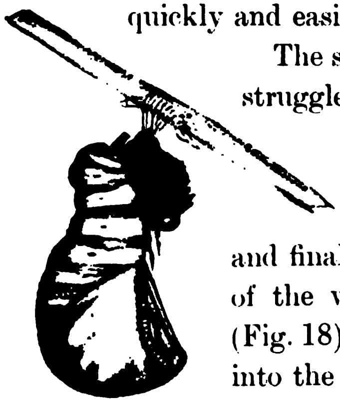


FIG. 17.—Chrysalis fastening hooks of cremaster into button of silk above. Drawn from under-exposed photograph.

The slender black end of the chrysalis struggles out from the shriveled skin, reaches up and around, stretches up, makes effort after effort to reach the silk (Fig. 17), and finally one great upward movement of the whole chrysalis sends the hooks (Fig. 18) of the cremaster of the chrysalis into the silk. Then the chrysalis works vigorously to remove the old skin, and not until it succeeds and the skin falls does the chrysalis cease moving energetically back and forth.

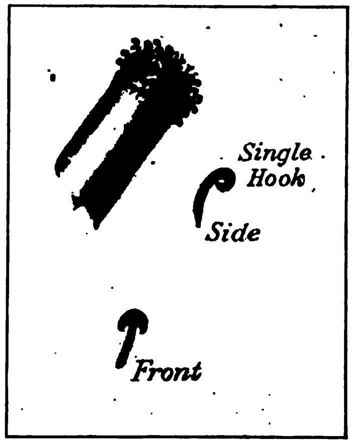


FIG. 18.—End of cremaster with hooks. Greatly enlarged.

This fifth and final moult of the skin is accomplished in from three to six minutes. After it, the chrysalis remains passive; it shortens very much owing to a contraction of the segments of the abdomen; there seems to be a blending of the various parts, so that although all the butterfly parts are distinguished, they are far less conspicuous than they were at first. The exterior hardens, becomes shining emerald green, and gradually the various yellow spots take on a metallic luster, and we have a veritable green and

gold jewel, one of the most beautiful objects in nature (Fig. 19).

But why did not the chrysalis fall? Can you tell? And, by the way, the chrysalis very often does fall, if the skin is too dry or for any reason the process takes too long. Notice that the chrysalis remains attached to the caterpillar skin far up on the ventral side until the cremaster hooks are in the silk, and in fact until the violent struggles of the chrysalis free it from the skin. As the separation between the skin and the chrysalis takes place note the white fibers of attachment as they give way, and note on the chrysalis the flattened place with the black spots just below the cremaster on the ventral side, which was the point of attachment to the skin (*A* in Fig. 19).

FIG. 19. Monarch chrysalis. Green with golden spots. Drawn from photograph.

Great changes took place under the caterpillar's skin during the latter part of its existence, for surely this chrysalis is the sleeping butterfly (Fig. 20): all its parts are plainly discernible. But the caterpillar was the young butterfly also, a fact less easily realized. The realization is helped out by the knowledge that the wings exist in the caterpillar, very minute, mere folds of the inner skin in the second and third segments, but the undeveloped wings none the less. The Monarch sleeps in its green and gold house for a week or ten days. Because of the absolute quiet of the chrysalis we are apt to think of it as not alive. But the butterfly is breathing; its blood is circulating; many of the life processes are in operation; it

is thoroughly alive. And, besides, further development is going on, which will make it the perfect butterfly.

After the chrysalis has hung motionless for a week, more or less, the time depending somewhat on the temperature, dark coloring appears, first down the lines of the antennæ and legs and "tongue," thence gradually spreading over head and wing regions, and finally up the dorsal side

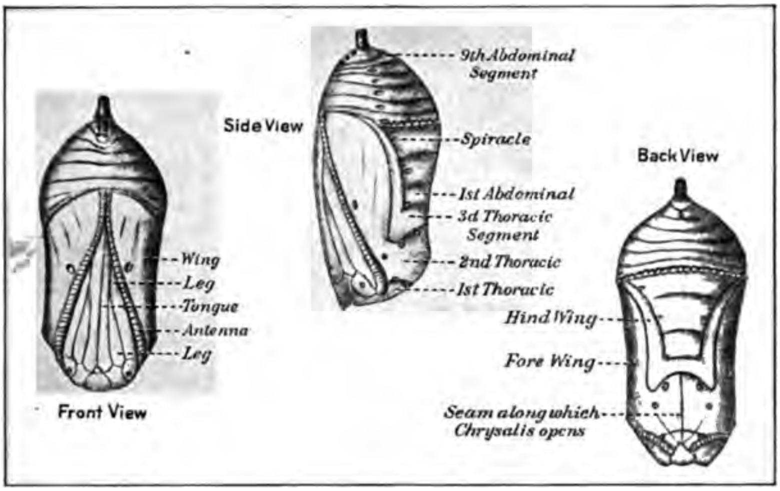


Fig. 20. — Front, side, and back views of the chrysalis to show various butterfly parts. Compare with Fig. 9.

of the abdomen and around until all tint of green is gone. By this time the black veins of the wings with the brown between begin to show through as well as the white spots In about twenty-four hours after the first appearance of dark color in the chrysalis, the butterfly is ready to escape, and can be seen plainly through the outer skin (Fig. 21).

There has been no sign of life for a week or more. The chrysalis still hangs motionless. As we watch, a rent appears along the lines between antennæ and wings. The breach widens. That part of the chrysalis which covered

FIG. 21. — Chrysalis showing butterfly through. Photographed from life.

FIG. 22. — First split in chrysalis. Photographed from life.

FIG. 23. — To show transparency of chrysalis skin, and emergence of butterfly. Photographed from life.

the antennæ, legs, tongue, and eyes moves slowly, mysteriously outward like a door opened from within (Figs. 22 and 23). Now movement becomes very rapid. The head is withdrawn from its covering as from a hood; one antenna is free, the other is free; the feet struggle out from their cases and immediately seek support on the outer part of the chrysalis; the wings are free — small, soft, and brown; the long, large abdomen is finally pulled out from the upper part of the chrysalis, and the butterfly crawls up the empty chrysalis skin to some more firm support, from which it hangs wet and helpless.

The one from which the photographs were made moved so rapidly that the photograph in which the butterfly is just leaving the chrysalis (Fig. 23) is not distinct in its details. The butterfly fell in trying to reach some support above the chrysalis and was placed on a clover blossom near (Fig. 24). Let us watch it for a few minutes. It hangs heavily from the clover.

The body is large and heavy, the wings hang straight down, and although they have expanded considerably since they came from the chrysalis, they are still small. The antennæ hang down with the wings.

The butterfly seems to be having trouble with its "tongue." This "tongue" is made up of two long pieces, grooved, and with curved teeth along the edges; the butterfly must fasten the grooved sides together to form a tube by dovetailing the teeth of the margins (Fig. 25), and then the whole must be coiled, like a watch spring, between the palpi. It is interesting to watch the process. The two pieces are placed together and again separated—something wrong. Placed together again and coiled, uncoiled and separated—not yet right. This is repeated again and again, sometimes for a quarter of an hour or more, before the butterfly is comfortable.

FIG. 24.—Monarch butterfly a few seconds after leaving chrysalis. Photographed from life.

But look at the wings! They are rapidly increasing in size, and in strength also, for now the butterfly can fan them back and forth. The increase in size is due to the fact that quantities of blood are pumped into them from the body, which becomes correspondingly smaller. The

increase in strength is due to this circulation of blood, and to the fact that exposure to air causes the chitinous covering to begin to harden and give firmness to the wings as well as to the body.

In half an hour the butterfly seems fully developed, although it is usually much longer before flight is

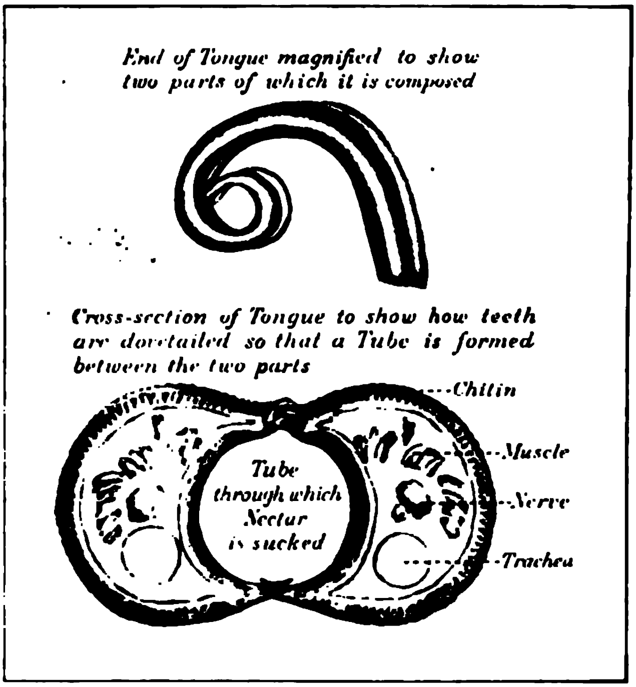


FIG. 25. Butterfly "tongue." Greatly magnified.

attempted. But the wings are dry and fully expanded; the antennæ no longer droop, but are held upright; the "tongue" is nicely coiled between the palpi, and the abdomen is much contracted and no longer shows from below, but lies above in a groove made for it by the posterior wings (Fig. 26).

This is our Monarch at last! From the little egg that was laid some three weeks ago! And it is very

beautiful. It is ready to go out and make "sunshine in a shady place," and sunny places still more sunny. The empty, colorless chrysalis is left hanging from its support; even now it is dry and curled. It tells a long story (Fig. 27).

The caterpillar has become the butterfly. The anterior three segments have become the thorax, the remaining

Fig. 26. — Monarch butterfly one-half hour after emergence from chrysalis. Photographed from life.

nine are the abdomen. The arrangement of spiracles is just as before. The three pairs of jointed "true legs" have developed into the butterfly's legs; the prolegs have disappeared. Two pairs of wings have been formed on the second and third segments of the thorax. The antennæ are greatly developed. Instead of strong mandibles, a long proboscis has been made, which, together with the

wing structure, will necessitate habits of life vastly different from those of the caterpillar. The metamorphosis is complete.

The controlling forces in the life histories of all our butterflies and moths have been the questions of food for their young, their protection from insectivorous foes, and the protection from the cold of winter. The struggle for existence in the case of the Monarch has resulted in this nauseous quality which gives it immunity from many of its foes; and in migration which gives more room to live in during the breeding season and so more food for the young, and also gives protection against the cold of winter.

FIG. 27. Empty Monarch chrysalis.

So in a way the Monarch's race is a favored race; that is, it is so admirably adapted to withstand cold and enemies that it is likely to survive while other races less favored may die out. It is protected even by the fact that its food in the larval stage is one of the most common weeds the world over. The Milkweed caterpillars are not likely to be molested because of the value of the plants they feed on.

The individual life of the adult Monarch is longer than that of most butterflies; it may extend from one summer, on through the winter, until the next spring. Of course its size when it leaves the chrysalis is its permanent size; a small butterfly never becomes a large butterfly. All growth and development take place in the caterpillar and chrysalis stages. The male butterfly is usually much smaller than the female.

There is a most striking case of unconscious protective mimicry of the Monarch butterfly in the Viceroy,[1] which has the same range as the Monarch.

This butterfly (Fig. 28) has not the nauseous quality that the Monarch has, but it is protected from its foes by

FIG. 28. — Viceroys at a feast. They can be distinguished from the Monarch by the black cross bands on the posterior wings. Photographed from life.

its close resemblance to the poisonous form. When in the hand it is easily distinguished by the dark cross bands on the posterior wings and by its smaller size, but when

[1] *Limenitis disippus* (Li-men-i′tis di-sip′pus), or *Basilarchia archippus* (Bas-i-lar′chi-a ar-chip′pus).

flying at a little distance the mimicry is thoroughly deceptive. The close resemblance has been brought about by a long process of natural selection; it began with a chance slight resemblance. In each generation the butterflies bearing the greatest likeness to the Monarch were protected by this likeness, and so survived; heredity did the rest. Now it is the best instance of protective mimicry among insects in the United States and one of the best in the world.[1]

[1] Read Chap. VI, Scudder's "Life of a Butterfly."

THE BLACK SWALLOWTAIL, OR ASTERIAS BUTTERFLY

FIG. 29. — Adult Asterias caterpillar in resting position. Length 2 inches. Green, banded with black, with orange spots in the black. Slightly enlarged. Photographed from life.

THE BLACK SWALLOWTAIL[1]

Seeing only what is fair,
Sipping only what is sweet.
EMERSON.

FOR September study, the Black Swallowtail, as well as the Monarch, is especially appropriate. The caterpillars can be found in abundance feeding on wild carrot and on the parsley and carrot of the garden. In fact, Asterias is another butterfly "botany teacher"[2]: the eggs are laid on the various members of the Umbelliferæ and on no others; on carrot and parsley and dill, on anise, caraway, and parsnip, on poison hemlock and fennel, and so on through all the list of members of the parsley family. The butterfly never makes a mistake. If we find the eggs or caterpillars of Asterias on any plant, we may safely conclude that it has honorable standing in the parsley family.

The eggs are laid singly on the undersides of the leaves. They are smooth and round and have no markings of any kind. They hatch in from eight to ten days. The little caterpillar is black, with a white saddle midway its length (Fig. 30), and as long as it keeps this dress it is well protected. It is angular and has six longitudinal rows of short fleshy spines, which are black except in the

[1] *Papilio asterias* (Pa-pil'i-o as-te'ri-as), or *Papilio polyxenes* (P. po-lyx'e-nes), of the family Papilionidæ; read page 375, Comstock's "Manual for the Study of Insects."

[2] Read Chap. IV, Scudder's "Frail Children of the Air," Houghton, Mifflin & Co.

region of the saddle, where they are white. The spines often have orange-colored bases.

The adult dress is very different. The caterpillar is quite smooth. It is largest at the anterior end. The ground color is green, with bands of black which have in them spots of yellow or orange. These orange spots may be wholly surrounded by black, or they may open broadly into the green (Fig. 29), so that the black band is broken crosswise into distinct parts. There is great variation

FIG. 30. — Young Asterias caterpillars. Black, with yellowish-white saddle. Natural size. Photographed from life.

amongst these caterpillars. There may be these two types, and a third type in which the caterpillar is almost black, with the orange spots mere pin points in the black, as in Fig. 31.

The Asterias caterpillar is protected by a very disagreeable odor which is given out from a pair of orange-colored flexible horns. These are united at their bases to form a Y-shaped organ, and are concealed in a sheath just back of the head. These horns, or osmateria (os-ma-te'ri-a), are about half an inch long. They are protruded on slight provocation (Fig. 31), though not often to their full length, then quickly concealed again.

The fundamental structure of the Asterias corresponds exactly to that of other caterpillars. (Refer to Monarch.) The caterpillars of all butterflies are alike in the number of segments, in the number and position of the true legs, prolegs, and spiracles, in the general position of the simple eyes, of the mandibles, and of the spinneret (Fig. 32). They also correspond exactly in the general uses of these parts, so that if we know one caterpillar, we know virtually all caterpillars, except in some few details which show the adaptation of the individual to its particular life.

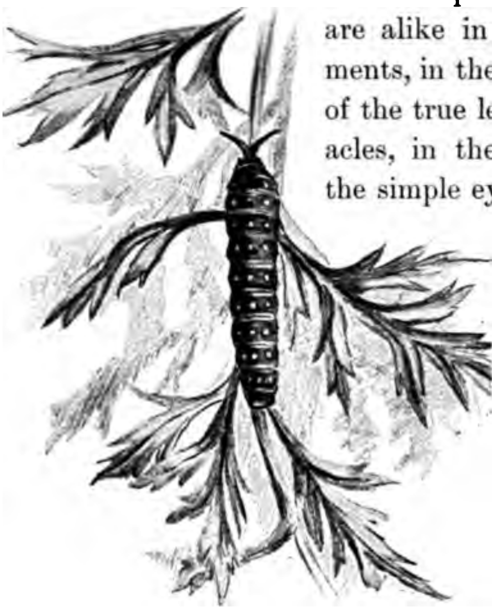


FIG. 31. — Full-grown Asterias caterpillar, to show variation from type. Black, with minute orange spots. Orange horns (osmate'ria) protruded.

It is most interesting to watch the larva of Asterias eat the finely divided leaf of wild carrot. Not a fragment is wasted, although there are so many chances for cutting off parts.

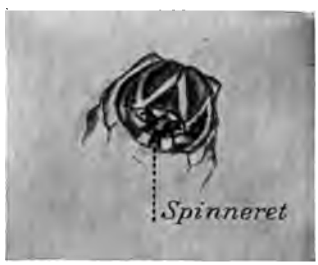


FIG. 32. — Asterias head, to show spinneret. Enlarged.

The caterpillar is likely to begin eating the leaf by attacking one of the lower divisions, as No. 1 in Fig. 33. This is held between the true legs, and the mandibles cut it

off in parallel lines until *a* is reached. As soon as the caterpillar feels the cut, even with this rib, it stops and attacks 2. This is surprising, but perhaps chance. Let us watch. No. 2 is cut off in the same way, and as soon as the caterpillar feels the mandibles touch the central rib at *b*, again it stops and attacks 3. It would be so easy to make one more sweep with the mandibles and let the whole end of the leaf fall! No. 3 is treated in the same way till *c* is reached. 4 is eaten off to *d*; 5 is attacked, cut off down to *e*, then *e* is eaten down to the point where 6 joins the rib. This is clever! No. 6 is eaten to the rib, rib disposed of to 7; 7 is cut off down to rib, rib eaten to 8; and so on to the main stem. There is never a false sweep of the mandibles; all is eaten, none is wasted.

FIG. 33. — Part of wild carrot leaf, to illustrate the caterpillar's way of eating.

The caterpillars feed and rest on the upper sides of the leaves, never seeming to attempt concealment, and as they are certainly rather conspicuous, they must depend on the protection given them by the offensive odor of their orange horns. They do most of their feeding at night and are very quiet during the day, very often resting for hours on the stem immediately under the umbrella of flowers of the wild carrot.

The moults take place in full view on the stems and leaves of the upper parts of the plant. The carpet of silk is spun, as it is by other caterpillars under similar

circumstances, and the head and body skins are moulted separately. The caterpillar does not devour the cast-off skin, but leaves the tiny black shriveled mass clinging in the carpet of silk until wind or rain disposes of it.

If the caterpillar is in captivity when the final moult or change to chrysalis approaches, we are warned by the very same conditions which exist in the case of any caterpillar approaching this change. The caterpillar pays no attention to food and becomes very restless; the alimentary canal is thoroughly emptied in preparation for the long sleep; the colors are dulled, the whole caterpillar is contracted. In nature the caterpillar is most likely to seek some neighboring fence or house and take a vertical position in some protected place, or a horizontal position under some support. After observing some six or a dozen chrysalides formed, we should perhaps say that they always take a vertical position, or they always take a

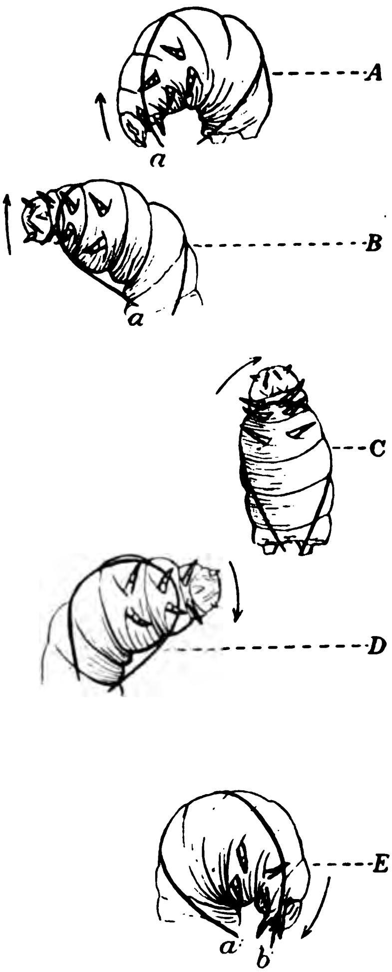


FIG. 34. — To show movement of caterpillar in spinning loop. Looked at from anterior end. Compare with Figs. 35 and 36.

horizontal position, but after seeing the process repeated some two hundred times we find that there seems to be no law, that with the same conditions one position may be taken by one caterpillar, and another by the next.

The posterior prolegs are fastened in a button of silk, and the caterpillar rests for some two hours. Then it begins moving its head about, and if we watch we soon see that there is some system in the movements. The head is moved around to one side until it covers a point on the support a little at one side of the mid-line of the body, and somewhat in front of where the first pair of prolegs is attached; here a thread of silk is fastened (*a* in *A* of Fig. 34). The caterpillar now moves its head away from this point, spinning a thread of silk (*B*) out as far as it can reach, remaining fastened by the prolegs (*C*); the ventral surface of the anterior part of the body is arched, lifted as high as the caterpillar can lift it, and held in that position; then slowly the head is moved around to the other side (*D*), the thread of silk being caught and held by the second pair of true legs. At a point on the other side corresponding to the first point of attachment of the thread, it is again attached (*b* in *E*, Fig. 34, also Fig. 36). Thus a loop is formed embracing the arched ventral part of the caterpillar's body, and this loop is held by the second pair of true legs, which bend forward so as to form a pair of hooks (Fig. 35). The movement is reversed, and a second loop of silk adhering closely to the first is made to pass from *b* to *a* (Fig. 34).

FIG. 35. — Asterias caterpillar spinning loop. Viewed from the side.

The loop is strengthened again and again, until it is a gleaming white rope made up of twenty-five or more single threads. Five minutes is the time usually taken to spin this loop.

Fig. 36. — Asterias caterpillar attaching thread of loop at side. Viewed from the side.

Finally, when the caterpillar is in position, as in Fig. 36, or *A* of Fig. 34, unexpectedly, by a very quick movement, the head is put under the loop, which is slipped over the anterior part of the body until it rests in the groove between the fifth and sixth segments. The head is curved forward so as almost to touch the support, the caterpillar becomes still more contracted, its colors still more dulled, and this position is kept without event for twenty-four hours (Fig. 37). At the close of this time the skin is moulted, and the chrysalis is revealed.

Fig. 37. — Asterias caterpillar ready for change to chrysalis.

The spinning of this loop seems one of the most wonderful feats accomplished during caterpillar life. It is difficult and is done once only; yet it means life to the caterpillar if it be done without mistake, probable death if there should be a slip anywhere. And it is done as easily as though the caterpillar had been well taught and had practiced many times.

Never but once have I seen a caterpillar show difficulty in managing the affair. One

caterpillar spun its loop a trifle too short, so that when it bobbed its head under and tried to slip the loop over to the sixth segment, it found itself too large to get through the loop, even with its most vigorous efforts. Twice the silk girdle was brought back to its original position over the arched ventral part of the body, held by the second pair of legs, and the head was pushed under; but not till the third effort did the caterpillar succeed in getting it satisfactorily placed.

FIG. 38. — Beginning to moult. For series of drawings to show moult, refer to Fig. 53. Drawn from photograph from life.

In this final moult the chrysalis has to work very hard. The bulk of the body is again and again slipped forward in the loosened caterpillar skin, so that this becomes tensely stretched over the anterior end, and very much wrinkled at the posterior end (Fig. 38). The skin splits back of the head and is forced back by its own taut condition and by the efforts of the chrysalis, until only the extreme posterior end of the chrysalis is within it. Then the chrysalis withdraws this posterior end, with its hundreds of tiny hooks, from the skin on the dorsal side and, reaching around, securely fastens the hooks into the button of silk. Then the old skin is removed both from its fastening to the chrysalis and from its attachment in the button of silk (Fig. 39). (Refer to

FIG. 39. — Asterias chrysalis. Slightly enlarged. Photograph.

Fig. 53 to see same process in the Yellow Swallowtail butterfly.)

But the chrysalis sometimes does not succeed in landing the hooks of the posterior end in the button of silk before the attachment between the skin and its body is broken and all its energy is gone. This is especially true when the caterpillar has chosen a horizontal surface. It may hang supported in the loop (Fig. 40) for a day or more, until the silk has cut far into the soft chrysalis,

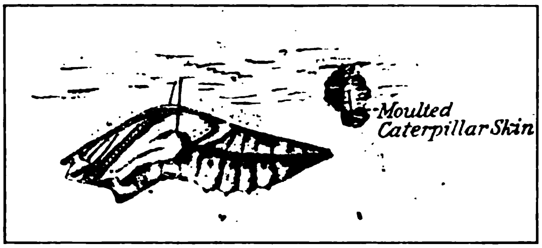


FIG. 40. — An Asterias chrysalis that was unsuccessful in fastening its posterior end in the silk.

and then by a second effort, brought about by the discomfort of the unnatural position, the hooks may be securely fastened in the silk, and the old skin forced from its support.

The chrysalis may not only fail in fastening the posterior end in the button of silk, but it may fall through the loop, perchance catching the hooks in the carpet of silk as it falls (Fig. 41), but more likely dropping to the ground to be destroyed in some way.

The various parts of the undeveloped butterfly, all folded closely to the body to take up as little space as possible, show very distinctly on the surface of the chrysalis (Fig. 40). This chrysalis is green, tinged with yellow

on the dorsal side; or it may be brown, with green spots and black streaks. With this coloring and its hard and rough exterior it resembles very closely a fragment of wood or bark, and so is well protected. One of these chrysalides looks so like a bit of wood that sometimes even an Asterias seems to be deceived by it and spins a carpet over it, attaching its loop of silk so that we have one chrysalis fastened to another (Fig. 42).

Fig. 41. An Asterias chrysalis that slipped through its loop and caught its end in the carpet of silk.

This butterfly is double-brooded in New England. In the July brood the chrysalis stage lasts somewhat less than two weeks, but in the fall brood it is the stage which carries life over the winter. We must keep the chrysalis for spring study.

Fig. 42. One Asterias chrysalis attached to another. Photograph.

In May the little fragments of green stem or of brown bark will suddenly become black, with rows of yellow spots, and will be soft to the touch. The chrysalis skin is separated from the butterfly within, and it will be a matter of a few hours only before the glorious Black Swallowtail will come forth, ready for a life of sunshine

FIG. 43. — The Black Swallowtail or Asterias butterfly. Male. 3¼ inches; black, bordered with double rows of yellow spots; a red eye-spot at the anal angle of each posterior wing; blue on the posterior wings between the rows of yellow spots. Natural size. Photographed from life.

and flowers after its long winter sleep (Fig. 46). And woe betide the butterfly if the chrysalis has become broken from its support, so that the butterfly cannot pull itself out, but must walk about with the chrysalis skin clinging to its wings until it is too late, and these wings have hardened, not in their expanded perfect condition, but wrinkled and folded so that the creature can never fly.

We all know the Black Swallowtail (Fig. 43). From its great abundance in the north, its striking appearance, and the fact that its larva feeds on garden vegetables, it is probably known to more people than almost any other butterfly. It is large, measuring some three and a quarter inches across the expanded wings. The posterior wings are smaller than the anterior, and each has, extending from the middle of its hind margin, a slender tail a half inch long. The wings are black, bearing along their edges double rows of yellow spots. The inner row on the posterior wings is especially conspicuous in the male, but may be almost lacking in the female. On the posterior wings the space between these two rows of yellow spots is dusted with blue very prominently in the female, less so in the male. At the anal angle of each posterior wing is a red eye-spot: this is true in both sexes. The under surface resembles the upper in general effect, but much of the yellow is replaced by orange-red, especially on the hind wings.

The life history of Asterias is somewhat different in the south; there are three broods, and the adult butterfly hibernates. In the north we may see the butterfly on the wing from May until the middle or last of September. For study we can have the butterflies in September, and the caterpillars and chrysalides then and later; in fact, the caterpillars have been found as late as the last of December, having fed on parsley that had been protected for winter use.

The Asterias butterflies are very fond of the nectar of garden flowers, and more than repay, by the work of cross-pollination that they do, for the amount of parsley and carrot eaten by their larvae. They help make possible

many races of flowering plants which are absolutely dependent on them and other butterflies to carry the pollen which will help make their seeds. The Agricultural Department at Washington accuses them of injuring some flowers, by tearing them as they remove the long "tongues" from their depths.

Every creature has many enemies. The student of nature becomes very familiar with this fact. Not only does each living thing have a hard time in finding and keeping a proper place to live in, and in getting the right kind of food and enough of it, but it must always be on the alert to elude its enemies. Caterpillars have many enemies, and on the whole they seem rather helpless in any sort of defense. Their great protection lies in hiding, and in their resemblance to their surroundings; a favored few, such as the Milkweed and the Asterias caterpillars, are protected by disagreeable odors or nauseous qualities. But who are the enemies of butterflies and moths in the adult and in the larval stage? Insectivorous vertebrates, such as the lizard, which are most common in the south; and birds; and various insects which are parasitic while in the larval stage.

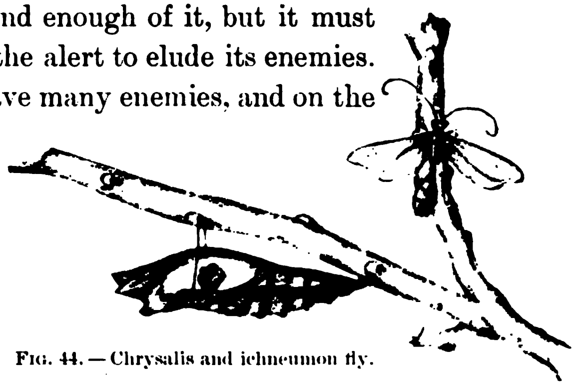


FIG. 44. — Chrysalis and ichneumon fly.

In the case of the Asterias caterpillar its offensive odor given off by the orange horns may protect it from insectivorous vertebrates and from birds, but it certainly does not from parasitic insects.

If we gather fifty Asterias caterpillars and have fifty chrysalides formed, we must not expect fifty Black Swallowtail butterflies. Some of the caterpillars were "bewitched" before we found them; and out of their chrysalides will come ichneumon flies (Fig. 44), orange-bodied, wasp-like creatures, which are restless and eager to fly out to find other Asterias caterpillars to "bewitch" (Fig. 45).

The ichneumon fly seeks until it finds an Asterias caterpillar; with a sting-like organ it deposits an egg in the

FIG. 45. Ichneumons from Asterias chrysalides. × 2.

body of the caterpillar and departs. The egg hatches into a minute grub that lives within the caterpillar, feeding upon it, but without injuring nerves, blood vessels, or any vital parts.

The parasite thrives, passes through its transformations, matures, and after the Asterias changes to the chrysalis form and can no longer supply food enough for itself and its parasite, the butterfly life is sacrificed and there comes forth from the chrysalis an adult ichneumon fly.

Certainly the Asterias has a hard time. Out of sixty or more eggs that may be laid, probably only three or four

butterflies ever reach maturity. Their parasitic enemies are so powerful that although the Asterias caterpillars feed on celery, parsnips, caraway, and many other cultivated plants, they seldom become a serious pest.

The Black Swallowtail butterfly is common all through the Atlantic States and the Mississippi Valley. It has

FIG. 46. — Asterias butterfly just out of its chrysalis skin. Slightly magnified. Photographed from life.

many near relatives. They are all large, showy butterflies, distinguished by the tails on the hind wings. There are about twenty-five kinds of Swallowtail butterflies in America north of Mexico, very many more than in all Europe. But in the tropics, especially in India, these butterflies are not only in much greater numbers than in America, but attain most wonderful size and brilliancy of color. Some measure eight or nine inches across the expanded wings and are called "bird-wing" butterflies.

THE TIGER SWALLOWTAIL, OR TURNUS BUTTERFLY

FIG. 47. — Tiger Swallowtail, or Turnus butterfly. Yellow with markings of black. Natural size. Photographed from life.

THE TIGER SWALLOWTAIL[1]

The larva of the Tiger Swallowtail, or Turnus butterfly, is one that is often found hurrying along on the sidewalks or fences in late September. It is a most curious and interesting caterpillar, and it will amply reward us if we take it home and watch it for a few days, and then keep the chrysalis till spring. For this hurried journey is surely in search of a protected place in which the chrysalis can be formed. In the spring this chrysalis develops into the yellow Tiger Swallowtail (Fig. 47).

The caterpillar, when ready for its moult to the chrysalis, is brown, with two great eye-like spots — which, of course, are not eyes — at the anterior end (on the third segment).

FIG. 48. — Turnus larva in resting position. Green or brown, with two eye-like spots on third segment, and small lavender spots on the sides.

Back of these there is a distinct white band (between the fourth and fifth segments). And what do you think of this caterpillar (Fig. 48)? You will look far to see an uglier fellow. The head is reddish brown and is almost

[1] *Papilio turnus* (Pa-pil′i-o tur′nus), or *Jasoniades glaucus* (Jas-o-ni′a-des glau′cus).

concealed except when the caterpillar is walking or eating. Its eating days are over now, and its walking days will very soon be over too. The next time it needs to take a journey of any kind it will find itself furnished with two pairs of wings.

FIG. 49. — Angry Turnus caterpillar.

But if we thought it looked ugly in resting position, what do we think now after we have touched it lightly with a pencil (Fig. 49)? It certainly looks angry, like an ugly monster with a great head and two staring eyes. The anterior part is so swollen that all trace of segments is obliterated, and a black band is revealed back of the white one. Touch it once again, and now look (Fig. 50)! Two long orange horns come out just back of the head (Fig. 51, A), which is wholly concealed underneath, and the whole anterior part is lifted and moved from side to side in the most menacing way. Well, you are rather terrible, Turnus! I should not at all blame birds, ichneumon flies, and all your other enemies if they "took to their

FIG. 50. Turnus caterpillar with orange horns protruded. Angrier!

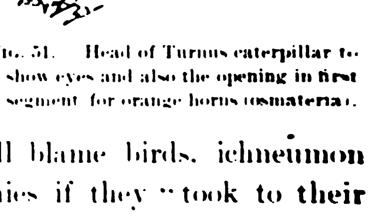


FIG. 51. Head of Turnus caterpillar to show eyes and also the opening in first segment for orange horns (osmateria).

heels" at sight of you. Phew! Especially if their sense of smell is highly developed. This Tiger Swallowtail must be nearly related to Asterias; at least the odor given out by the orange horns is similar.

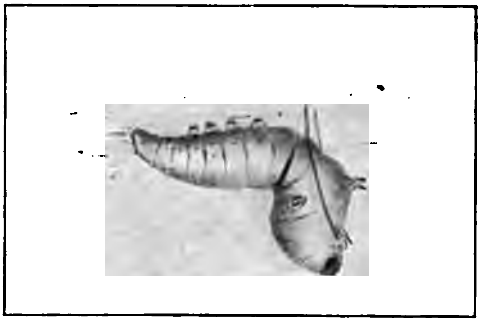


FIG. 52. — Turnus caterpillar with loop about arched ventral part of body. Loop is held by second pair of true legs. Viewed from side.

But our caterpillar is too intent on finding a suitable place in which to change to the chrysalis form to be angry long. The horns are concealed and the anterior end assumes its former size.

A horizontal position is chosen, possibly a vertical one; a carpet of silk is spun and the posterior prolegs are entangled in it; a loop is spun about the arched ventral part of the body (Fig. 52), the head is pushed under at one side, and the loop slipped over the body to the sixth segment (Fig. 53). (Refer to Figs. 34–37 to see the same process illustrated in Asterias.) The head is brought toward the support till it well-nigh touches it, the prolegs let go their hold, and the caterpillar swings out in its loop, fastened at the posterior end only. All is quiet. The colors fade, the brown becomes duller, the rows of lavender spots on the sides disappear.

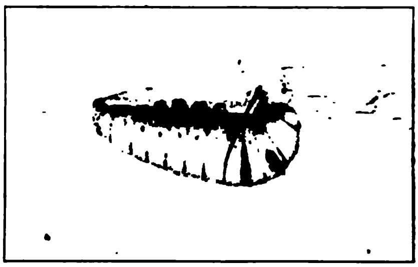


FIG. 53. — Turnus caterpillar swung in its loop and fastened at the posterior end ready for moult to chrysalis. Viewed from side.

The chrysalis within is loosened from the caterpillar skin: it forces the bulk of its body toward the anterior part again and again, until this skin is stretched at the anterior end and wrinkled at the posterior (Fig. 54, *A*). A conspicuous white stripe appears along each side of the caterpillar. What is it? It was not there before. It is conspicuous on almost all moulting caterpillars. The external chitin lines the spiracles for a short distance in from the surface, and these linings are, of course, without color; as the skin is loosened these colorless short linings are withdrawn; and as the skin is forced backwards they are flattened and drawn into line to form this white stripe.

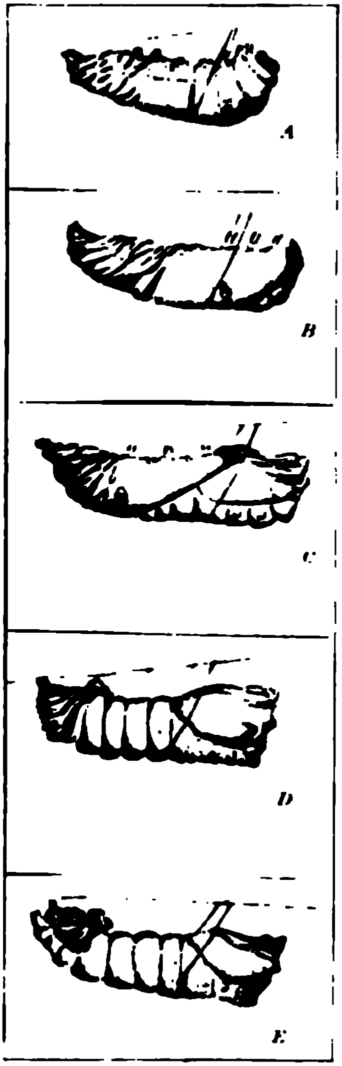


FIG. 54. Series of drawings to show moulting of skin to form chrysalis [illegible]

The skin has split back of the head, and the chrysalis is revealed (*B*). By the vigorous efforts of the caterpillar the skin is continually worked towards the posterior end. It slips past the girdle of silk (*C*) on into a small wrinkled mass at the posterior end (*D*). It must have been very thin. The end of the

chrysalis is withdrawn, it reaches around and under (*E*), and after many an effort the hooks at this posterior end are caught into the thick carpet of silk. The chrysalis now removes the shrunken skin both from its attachment to the body and from its attachment in the carpet of silk, and all is right.

The chrysalis (Fig. 55) resembles that of Asterias very closely; it is brown and angular, looking quite like a bit of rough bark. The chrysalides formed in the fall will not develop into butterflies until the following May or June.

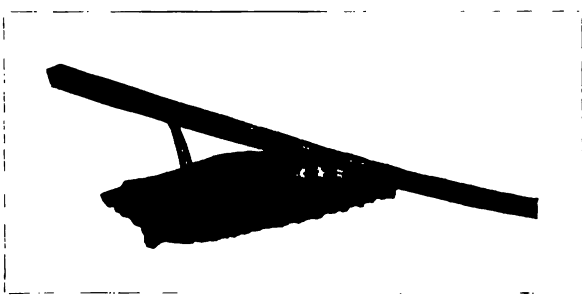


FIG. 55. — Wood-brown chrysalis of Turnus, the Tiger Swallowtail butterfly. Natural size. Photographed from life.

In temperate regions the butterfly is double-brooded. The eggs are laid singly on the leaves of the food plants. These food plants include representatives of more families than those of any other butterfly in our country.[1] Birch, poplar, and ash are said to be most commonly used by the butterfly, but I have found more Turnus caterpillars on wild cherry and shad bush than on any other plants.

The eggs are nearly spherical and are smooth and

[1] Read Chap. IV, Butterflies as Botanists, Scudder's "Frail Children of the Air."

green. They have many parasitic enemies so small that twelve to sixteen of the midgets may live in one egg.

The egg hatches in about ten days, and the little caterpillar shows marked resemblance to the young Asterias caterpillar. It is very dark brown, with a black head and a greenish white saddle midway its length (Fig. 56). It retains a dress similar to this until it is nearly half grown, then it loses all trace of the saddle (Fig. 57).

FIG. 56 - Young Turnus caterpillar, showing relationship to Asterias by its white saddle. × 2. Photographed from life.

The adult caterpillar is leaf-green in color, and is naked and smooth. The head is reddish brown, the anterior part of the body is greatly enlarged, has a white band between the fourth and fifth segments, and two great eye-like spots on the third segment. There is also a concealed black band just back of the white one, and there are rows of minute blue spots lengthwise of the body. When the caterpillar approaches the change to chrysalis its green becomes brown.

These Tiger Swallowtail caterpillars in all stages of their growth rest on the upper surfaces of leaves, depending on their color for protection. They are most interesting because of the habit of spinning a "spring bed" on which to rest. A caterpillar walks over the upper surface of a leaf toward the stem, fastening threads of silk across from right to left, but not gluing them to the leaf between the points of attachment; then it turns about and, going toward the point of the leaf, spins silk, fastening it at the right and at the left, a second layer

over the first. Wherever the threads of the second layer touch the threads of the first layer they are glued fast to them, so that a network is made. In this same way a third and a fourth, and still other layers of silk are laid down. The cross threads are shorter than the space under them and so draw the edges of the leaf somewhat together. A thick carpet is thus made, elevated a little from the surface of the leaf and stretched so tight that the edges of the leaf are curled upward, partially concealing the caterpillar. On this spring bed the caterpillar swings and rests, very well protected by its close color resemblance to the leaf (Fig. 57).

Fig. 57. — Green Turnus caterpillar (adult form) resting on "spring bed." ⅔ natural size. Photographed from life.

The Tiger Swallowtail must be pretty well known, for it is very widely distributed. It is found in nearly all parts of the United States, and in some localities at least it is extremely common. It is greatly attracted by many kinds of flowers, notably the lilacs, and by decaying animal matter, and sometimes gathers in hundreds and thousands. Scudder tells us that sixty-nine of these butterflies were captured by closing the two hands over them as they were feeding on a bunch of lilacs.

The Tiger Swallowtail is unusually large. The arrangement of colors can be made out from Fig. 47. The butterfly is especially interesting because of the dimorphism that

exists in the female. In temperate regions the female is like the male, but larger; in the south there is a female form which has the yellow of the wings so dusted with black that the stripes are scarcely visible.

The Turnus butterflies are eminently social. They are bold and careless fellows; at one moment flying so low that we may catch them in our hands; at the next they are twenty feet or more above us and soon soar far beyond sight over trees and dwellings.

Another Swallowtail butterfly of great beauty is the GREEN-CLOUDED or TROILUS butterfly[1] (Fig. 60). The caterpillar can be found in September and early October feeding on the sassafras or the spice-bush, and is most interesting and amusing.[2]

FIG. 58. — Troilus larva. Green, with eye-like spots on third segment. When ready for chrysalis becomes orange-colored. Photographed from life.

The enlarged anterior part and the concealed orange-colored horns show its relationship to Turnus and Asterias. It resembles Turnus in having large eye-like spots on the third segment (Fig. 58). It has the habit of spinning a carpet of silk on one side of a leaf, stretching the threads so tight that the edge of the leaf is not only curved upward, but also over, to form a

[1] *Papilio troilus* (Pa-pil'i-o troi'lus), or *Euphoeades troilus*.

[2] Read Scudder's "Everyday Butterflies," pp. 138–145.

FIG. 59. — Troilus chrysalis. Smooth and brown. × 1⅓. Photographed from life.

FIG. 60. — Green-clouded Swallowtail, or Troilus butterfly. Photographed from mounted specimen.

covered house for the caterpillar. It is Gibson's "Bugaboo of the Spicebush."[1]

[1] Gibson's "Sharp Eyes," pp. 132–135.

The chrysalis is quite different from that of Turnus or Asterias. It is smooth, brown, and delicate, with the head prominently lobed (Fig. 59). The chrysalis is one that shows very plainly a crescent-shaped spot over the eye of the sleeping butterfly. This is supposed to be the remnant of a chrysalis eye, and is interpreted to mean that at some time in the past ages the chrysalis led an active life. Many chrysalides have these crescent-shaped spots showing conspicuously.

THE MOURNING CLOAK, OR ANTIOPA BUTTERFLY

FIG. 61. – The Mourning Cloak. Expanse 3 inches. Wings brown, with yellow edges, and blue spots in the darkest part of the brown next the yellow. Natural size. Photographed from life.

THE MOURNING CLOAK [1]

If we go to the woods on a sunny day in March, we shall find many evidences of spring; the skunk cabbage reveals its rolls of green and its maroon hoods, and from the alder branches above the redwings call; a woodpecker drums on a tree trunk far above, and the sun shines through the bare branches of the trees to the green moss at their feet and the carpet of brown leaves between. After the winter all is

> "So nigh to the great, warm heart of God,
> You almost seem to feel it beat
> Down from the sunshine and up from the sod."

Most spring-like of all are the butterflies there. Large brown butterflies, with wings edged with yellow, flutter and sail low over the brown leaves to settle on them and rest with wings spread wide to the sunshine.

And here is a group of them on the trunk of a white birch; they are quiet, with wings closely folded above their backs and with their long black "tongues" uncoiled. The uncoiled "tongues" tell the story: the tree has been injured at this point, and the Antiopa butterflies are at a feast, busily drinking the sweet sap as it oozes out; and this is the secret of their food supply in spring before the arbutus and the pussy willows and the other early flowers appear.

"Mourning Cloak" is the common name of the butterfly, but it seems an ill-fitting one; "Yellow Edge," the

[1] *Vanessa antiopa* (Va-nes'sa an-ti'o-pa).

Euvanessa antiopa

country boy's name for it, sounds better; or "Camberwell Beauty," the name given the species in England.

This butterfly (Fig. 61) measures three inches across the wings. Its first pair of legs is greatly undeveloped, showing its claim to a place in the family of the so-called "Four-footed Butterflies,"[1] and the margins of the wings are conspicuously notched, explaining its membership in the group of "anglewings."[2] The dark-brown wings are yellow-edged and have conspicuous blue spots in the darkest part of the brown next the yellow. The under surface of the wings is dull brown, with the yellow edge much less conspicuous, and with the spaces between the veins closely crossed by thread-lines of black.

Fig. 62. — Mourning Cloak butterfly playing dead: hung by claws of hind feet on fringed gentian leaf. Natural size. Photographed from life.

The Mourning Cloak is protected by its shape and color in a marked degree. When the wings are folded above the back in resting position, never did any living thing look more like a fragment of brown wood or bark, and the resemblance is heightened by the habit of playing dead, which this butterfly always practices when disturbed. We may toss it from hand to hand, drop

[1] Nymphalidae, largest family of butterflies, Comstock's "Manual for the Study of Insects," p. 395.

[2] Vanessids, subgroup of Nymphalidae.

it into the grass as we would any dry chip, and it shows no more life than any chip would. We may hang it up by the claws of its feet (Fig. 62); still it shows no sign of life. This habit must be a great protection in its life, for we know that birds and other animals must, as a rule, be convinced by the motion of their prey that it is alive, or they disdain it.

This butterfly is of a sturdy race and hibernates in the adult form. We may see it flying in September, October,

FIG. 63. — Willing captives at dinner, December 25. (The Mourning Cloak.)

and even November, and again in February and March, or even earlier, if there happens to be a thaw;[1] in fact, just as dandelions amongst flowers have been reported for every month of the year in the Northern States, so Mourning Cloaks amongst butterflies have been seen flying every month from March to March again. We have seen that in the early spring, before the flowers come, they feed on the exuding sap of trees; in the late fall, after the flowers are gone, they seem perfectly content with the juices of

[1] Thaw Butterflies, Gibson's "Sharp Eyes," pp. 270–274.

decaying fruits, assembling in large numbers in orchards and about cider presses.

When the severe cold weather approaches they seek some sheltered cranny in piled wood or stones, in hollow trees, under the loosened bark of old stumps and trees, or on the rafters of barns; they have been found in all these and in other similarly protected places. Here they sleep, usually with folded wings hanging downward, enduring all the severe cold until the warmth of February and March days tempts them out in search of food.

We may keep them in the house all winter by feeding them on apple (Fig. 63), but they are best kept in some cold, dark place which will give them the natural conditions for hibernation.

In early May, when leaf buds are just opening, the eggs of Antiopa are laid side by side with great regularity in large clusters so that they encircle the twigs of the food plants — willow, elm, and poplar. The butterfly has two broods; in the case of the second, or summer brood,

FIG. 64. — Eggs of the Mourning Cloak butterfly on twig and leaf of poplar. × 2. Photographed from life.

the eggs are usually laid in close rows on the underside of a leaf (Fig. 64). It is an easy matter to see this process in nature as well as when the butterfly is in captivity;

the butterfly hangs from the leaf with wings folded, the abdomen is curved so that its end touches the under surface of the leaf. There is a pause of a few seconds after each egg is laid.

The eggs are oval and yellow in color and are placed on end. When examined closely they reveal eight or nine vertical ribs. In about two weeks the young caterpillars escape through holes made at the tops of the eggs. They at once arrange themselves side by side on the under surfaces of the leaves, all in compact rows, with their heads at the edges. They live in company through all their caterpillar existence, though scattering somewhat when near maturity, and, when the colony is a large one, considerable damage may be done to the branch or branches of the tree they occupy. They never try to protect themselves by hiding. When moulting time arrives all assemble on a branch, perhaps making it droop with their weight. Here they shed the skins, leaving the black, spiny masses clinging to the branch to tell the story.

FIG. 65. — Antiopa caterpillar. Black, finely dotted with white, with longitudinal rows of black, branching spines, and with eight red spots along middle of back. Photographed from life.

When mature they are two inches long and are covered by longitudinal rows of black, branching spines.

They are black, finely dotted with white, having eight orange-red spots along the middle line of the back (Fig. 65). The five pairs of prolegs are of the same orange-red color.

FIG. 66. Antiopa caterpillar in position to moult skin for chrysalis. Drawn from photograph from life.

When ready for the change to chrysalis they scurry away singly in search of a fence or stone wall or other protected place in which to spend the critical hours before and after the change.

The caterpillar hangs suspended, with its posterior prolegs firmly fastened in a button of silk and its body curved upward (Fig. 66). After twenty-four hours the caterpillar begins to be restless, straightening its full length and again curving its body upward. Finally the skin splits back of the head and is moulted exactly as in the case of the Milkweed caterpillar. If the skin is dry, or for any reason the conditions are not right, the process may end tragically; the chrysalis may fall, or it may not be able to extricate its posterior end from the caterpillar skin and so hardens with this end closely sheathed in its old skin (Fig. 67).

FIG. 67.—Chrysalis of Antiopa butterfly hardened with end sheathed in old caterpillar skin. Drawn from photograph from life.

The chrysalis is wood-brown and very rough and angular, the back bearing many short spines. It is distinctly a protected form. Still it hangs freely, suspended only at the end, so that if the time in this stage were several months instead of two weeks or less, the chrysalis would be likely to be battered to pieces, in spite of its angles and spines, by the buffetings given by the fall, winter, and spring winds. It is an interesting fact that not only in the Antiopa butterfly is the life not carried through the winter in the chrysalis stage, but in the case of all butterflies whose chrysalides are suspended by the posterior end only, the life is usually preserved over the winter season in some other than the chrysalis form.

FIG. 68. — Antiopa butterfly opening the door of its chrysalis skin. Photographed from life.

The chrysalides of the first brood mature in July or sometimes the last of June; the butterflies of the second brood push open the doors (the chitin covering head, proboscis, legs, and antennæ), and climb forth from their chrysalis skins in September and October (Fig. 68). It is no uncommon thing to see this final transformation of the Mourning Cloak taking place on fences and stone fronts of houses, as we walk in the very heart of any city where elms (their food tree) are used for shade.

Very soon after leaving the chrysalis, Antiopa voids a red fluid which resembles blood in color. All of the moths and butterflies on quitting the chrysalis skin send forth from the body a fluid very often red in color. Thus,

when any form is very common in a locality these spots of red on houses and fences where the insects have rested on coming out of the chrysalis skins may be numerous enough to give rise in the minds of the ignorant and superstitious to belief in a rain of blood, interpreted to foretell disaster. It is said that this mistake was made many times in the history of the world and many lives sacrificed because of it, before the real cause of the red rain[1] was found out.

The Mourning Cloak is one of the most common butterflies in the United States, as well as in various countries of the Old World. We can find almost no better material for study in spring or fall.

[1] Red Rain, Holland's "Butterfly Book," pp. 290–304. Doubleday & McClure Company

Ready for life.

THE PAINTED BEAUTY, OR HUNTER'S BUTTERFLY

FIG. 62. The Painted Beauty on purple aster. Under surface of wings. Conspicuous masses of rose color on the hind parts of the fore wings; two large eye-like spots on each posterior wing. Natural size. Photographed from life.

THE PAINTED BEAUTY [1]

The beautiful is as useful as the useful. — VICTOR HUGO.

A BUTTERFLY that is distinctively American, and that is found throughout the United States except, perhaps, in some mountainous districts, is the Painted Beauty. It is well named, for it is one of much beauty in all stages, as well as one of much interest.

A "butterfly born in a bower"! [2] And a most attractive little bower it is that the butterfly finds itself in as it opens the door of the chrysalis and climbs out; a bower so small that the owner must leave it to find space for the expanse of its wings.

If we examine the everlasting plants (*gnaphalium*) in September and October, we shall very often find hollow nests, all clean and white, made of large clusters of fragments of the everlasting flowers held together by slender threads of silk (Fig. 70); and if we make an opening and peep in, we are likely to find the caterpillar of the Painted Beauty (Fig. 71), or possibly the chrysalis.

When the nests are first made, they are compact and shapely, but after they have been at the mercy of the wind for some time they are frayed into artistic disorder, and send out long streamers, beckoning us to come and examine.

The caterpillar uses the nest as a resting place and a hiding place, and the neighboring leaves for its feeding

[1] Hunter's Beauty, *Vanessa Huntera* (Va-nes'sa Hun'te-ra), or *Pyrameis Huntera* (Py-ra-me'is Hun'te-ra).

[2] Read Gibson's "Sharp Eyes," p. 168.

grounds; so when we look inside we may find the tenant gone, and may have to search elsewhere on the stems and leaves of the plant. The full-grown caterpillar is one and one-half inches long, and is very gay-colored and conspicuous. It is banded with deep red and yellow, and is boldly

FIG. 70. — Nests of Painted Beauty caterpillars, on everlasting (*gnaphalium*).

spotted with silvery white. It shows relationship to the Mourning Cloak by the longitudinal rows of branched spines (Fig. 72).

The egg when laid is tucked down amongst the long hairs of the leaf. As soon as the young caterpillar comes from the egg, it makes a tent by biting off the long hairs and fastening them together by means of a close web

of silk. The little fellow lives in this tent until it has eaten all the pulp of the leaf under it, and then proceeds to make a new one. As the caterpillar grows a little older, the nest is sometimes made between two adjacent leaves, and finally we have the form in Fig. 70.

The butterfly has two broods; the summer brood feeds on *antennaria*, or "lady's tobacco," as well as on *gnaphalium*.

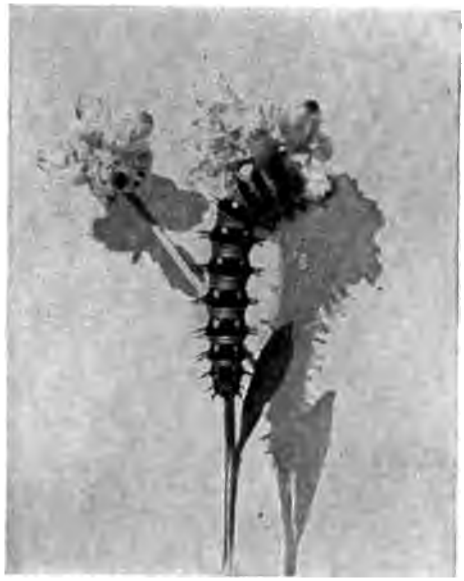


FIG. 71. — Caterpillar of the Painted Beauty, banded with dark red and yellow, spotted with white, with longitudinal rows of branched spines. 1½ inches. Photographed from life.

The story of the periodic moults and of the formation of the chrysalis is clear if we know the Monarch or the Mourning Cloak. The chrysalis (Fig. 73) is made in the nest, or sometimes on the stems of the food plant. It is extremely beautiful; small and angular, with two prominent projections at the head end. In coloring, it is a jewel indeed, gleaming with tints of green and bronze and gold. The chrysalis stage usually continues ten days or two weeks. The whole life history is worked out in the fall, the butterfly hibernating in the adult form. Its winter hiding places are not well known. It may prefer cozy hollows in trees, or protected places under large rocks, or dark corners of the rafters of barns. Who will find out the secret of its safe seclusion?

The butterfly is a most charming one. We can find it in large numbers in September and October on asters and golden-rods, on thistles and dandelions. It is extremely active and flies until a half hour before sundown. It

Fig. 72.—Angry Painted Beauty caterpillar. Photographed from life.

turns suddenly to right or left, reverses the course, returns to a point from which it has been frightened, and circles about; we try in vain to make the capture. It rests on an aster, puts the long proboscis into a nectar cup, folds the

wings above the back; and we may pick up the Painted Beauty between the fingers. If we do so, it at once appears lifeless; "playing dead" is one of its common means of escaping its enemies. If left quiet for a few seconds, it comes to life again and shows the curious rapid vibration of the wings preceding flight, which is so common a habit with moths. And again it is gone, as strong and free as ever.

The Painted Beauty is a butterfly of medium size, measuring two or two and one-quarter inches from wing tip to wing tip. The upper surface of the wings is nearly black, marked conspicuously with orange and white; the under surface (Fig. 69) is marbled and streaked with gray, white, and brown; there are conspicuous masses of rose color on the hind parts of the fore wings, and there are two large peacock-eye spots on each posterior wing near its hind margin. The harmony of coloring of the under surface is most pleasing.

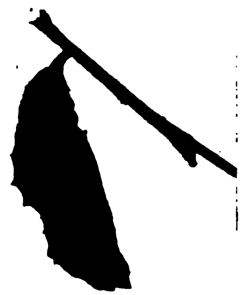


FIG. 73.—Chrysalis of the Painted Beauty. Green, bronze, and gold. × 1¼.

Another butterfly (Fig. 74) most nearly related to this one is the PAINTED LADY.[1] This is known as the Thistle butterfly also, since its larvæ feed on thistles. And because its larvæ feed on thistles, which are weeds the world over, this butterfly is more widely distributed than any other in the world; it is the cosmopolitan butterfly.

[1] *Vanessa cardui* (Va-nes'sa car'du-i), or *Pyrameis cardui* (Py-ra-me'is car'du-i).

Its life history and habits are very much like those of the Painted Beauty; if we know one, we need little introduction to the other. The butterflies are so alike that they are easily mistaken for one another. The Painted Lady has a row of small eye-like spots instead of the two large ones on the hind margin of the posterior wing. It is a butterfly whose migration in large swarms is well known. It hibernates in the adult form.

Fig. 74. — The Painted Lady, or Thistle butterfly. Coloring like that of Painted Beauty (Fig. 69); four peacock-eye spots on hind wing. Natural size. Photographed from life.

Another very closely related butterfly, which likewise is most common, is the Red Admiral[1] (Figs. 75 and 76). We all know the black, red-bordered, white-spotted wings which have gained for this butterfly its name, and if we know the life history and habits of any other member of the group of Vanessids, it is only in details that we need any introduction to this one. Its food plant is the nettle.

Here are only everlastings, thistles, and nettles; and at second glance only spiny caterpillars; but if we give our attention a little longer we shall find that this is surely a case of the marvelous and beautiful hidden by the common.

[1] *Pyrameis atalanta* (Py-ra-me-is at-a-lan'ta). Read Nettle-leaf Tent Builders, Gibson's "Eye Spy," Harper & Brothers.

FIG. 75. — The Red Admiral. Black; orange-red band on each wing; fore wings spotted with white. Natural size. Photographed from life.

FIG. 76. — The Red Admiral. Under surface. Photographed from life.

THE INTERROGATION BUTTERFLY

FIG. 77. The Interrogation butterfly, or Violet Tip. Dull orange-brown spotted and bordered with black. Hind wings edged with violet. Natural size. Photographed from life. (Refer to Fig. 82 for under surface.)

THE INTERROGATION BUTTERFLY[1]

In either June or September we may find the larvæ of the Interrogation butterfly feeding on the elm tree or on hop vines, and there is almost no other butterfly whose life history can be worked out more easily or quickly. The full-grown caterpillar is brown, with many inconspicuous light markings and longitudinal rows of branched spines placed somewhat far apart (Fig. 78). The head bears a pair of branching spines.

Fig. 78. — Full-grown caterpillar of the Interrogation butterfly. Brown, with inconspicuous light markings and longitudinal rows of branched spines. Photographed from life.

If we find one full-grown Interrogation caterpillar, we are likely to find in the same place others of the same size, and many younger ones of all sizes, for the eggs are laid in loose clusters and at short intervals; and although the caterpillars are not social in habit, living happily side by side as do Prometheas (Fig. 99), yet they live in close

[1] *Grapta interrogationis* (Grap'ta in-ter-ro-ga-ti-o'nis), or *Polygonia interrogationis* (Pol-y-go'ni-a in-ter-ro-ga-ti-o'nis).

proximity to one another. We shall find also the empty eggshells, for the Interrogation caterpillar does not eat the shell, as so many caterpillars do.

The eggs are laid singly, or in twos, or in even larger clusters (Fig. 79) on the upper surface at the tip of a leaf, on the midrib of the lower side at the tip or part way back, or even on the stem of the leaf; in fact, we may find them almost anywhere on the young growth of the elm or hops. The eggs may be piled one on top of another somewhat in the fashion of those of the Comma butterfly (Fig. 80). They are very beautiful — small gleaming jewels, tinged with green before the caterpillar escapes, but like small diamonds when empty. Each egg has its shining surface divided by ten ribs extending from the center of the top to the base.

FIG. 79. — Eggs of the Interrogation on a fragment of elm leaf. Magnified.

The young dark-colored caterpillar eats a hole in the egg just large enough to allow its escape and then takes position on the underside of a leaf. The caterpillars of all stages rest and feed on the underside of the leaves which we shall find eaten at their edges, or having large holes eaten through them. When at rest the Interrogation caterpillar always curves the anterior part of the body around to one side, so that it might well be named Interrogation from this habit. If disturbed, it quickly puts head to tail and drops to the ground; when young it drops on a thread of silk, on which it may safely crawl back after the danger is past.

FIG. 80. — Eggs of the Interrogation laid in piles, as are those of the Comma. Magnified.

The change to chrysalis is most easily observed in this species. In all main points the process is like that in the Monarch. It is a curious fact that the carpet of silk spun by the caterpillar as a support for the chrysalis is bright pink in color. The complete change occupies some twenty-four hours, the final moult usually taking place early in the forenoon.

We must look for the chrysalides (Fig. 81) on the stems and leaves of the food plant. They are light brown and

FIG. 81. — Interrogation chrysalides on hop vine. One at left is brown with golden spots (hop merchant), one at right is dark brown, showing butterfly through. Photographed from life.

very angular. Each has a double row of silver and gold spots on the back of the abdomen. The chrysalis, when examined closely, shows everywhere a fine tracery of dark lines. There are two pointed projections at the head end, and a curious projection from the back of the thorax, below the gold spots, which looks like a Roman nose. The fifth to the eighth segments of the abdomen have black-tipped spine-like projections on the back.

The chrysalis stage is usually of short duration, seven to eleven days, here as in all cases the time depending on the temperature. The chrysalis is a very active one. If it is disturbed in any way whatever, if a caterpillar touches it, if a fly alights upon it, if a stiff breeze blows, it swings forcibly and rapidly back and forth, and we at once see the use of the many points and projections. The soft parts of the butterfly do not extend into them: and loosely swung as it is from the posterior end, the chrysalis needs the protection given by them.

These chrysalides greatly resemble those of the Comma, which also feeds on hop. And these chrysalides, as well as those of the Comma, are termed "hop merchants." If they show a large amount of gold coloring, hops are to sell high, so say the hop-growers; if there is more silver than gold, hops will be low. Before the emergence of the butterfly the chrysalis loses its gold and silver and becomes everywhere deep brown in color (chrysalis at right in Fig. 81).

The Interrogation butterflies (Figs. 77 and 82) are the largest of the genus Grapta, which includes the Comma and several other common butterflies. The wings are very angular, the posterior ones extending into short tails. The upper surface of the wings is tawny brown, heavily spotted and bordered with black; the hind wings have a very narrow border of violet, which has given the butterfly the name of Violet Tip.

The under surface of each hind wing has in its center a silver mark like a semicolon (Fig. 82). The semicolon is the Greek interrogation point, hence the common name of the butterfly. It would be better to call it the Semicolon butterfly. There is a curious case of dimorphism

in the Interrogation butterfly; in one form the hind wings are of the same general color as the fore wings; in the other these hind wings are very dusky, almost black.

The Interrogation is double-brooded in temperate regions and passes the winter as a butterfly. Who will find its hiding places? It is on the wing until near the

FIG. 82. — The Interrogation butterfly. Under surface, showing silver semicolon. Photographed from life.

middle of October. It is found over the whole of the United States east of the Rockies, and is very common in gardens and along roadsides and in waste fields. It is very fond of fruit juices, as are so many butterflies, and in the early spring, before there are many flowers, it searches for injured trees from which it may get the sweet sap.

THE RED-SPOTTED PURPLE, AND THE VICEROY

(TWO SOVEREIGNS)

"Kill not, in Pity's sake, and lest ye slay
The meanest thing upon its upward way."

FIG. 83. — Young caterpillar of Viceroy butterfly,[1] resting on leaf which it has partly cut away in readiness for winter quarters. Photographed from life. (Refer to Figs. 88 and 89.)

[1] *Basilarchia archippus* (Bas-i-lar'chia ar-chip'pus), or *Limenitis disippus* (Li-men di-sip'pus). (Refer to Fig. 28.)

THE RED-SPOTTED PURPLE BUTTERFLY[1]

THE most curious and grotesque caterpillars that we can find in June and July (sometimes in early September) are the caterpillars of the Sovereign butterflies. The caterpillars of various members of this group, although they develop into very different butterflies, look so much alike that it is almost impossible to tell which one we have until it has reached the adult form. The various species are also very much alike in habit. If we find the caterpillar on cherry or apple, plum or shad bush, or any member of the rose family, we are rather safe in concluding it to be the larva of the Red-spotted Purple. If we find it on poplar or willow, we may be certain that we have the caterpillar of the Viceroy.

FIG. 84. — Larvæ of the Red-spotted Purple in one of its curious resting positions. Brown, green, and cream color. 2 inches long.

These larvæ are most curiously marked with shades of brown, olive-green, and rosy cream-color, and are covered with warts and tubercles and prominences of all sorts. The front of the body is enlarged and especially adorned by these prominences. In fact the creature is one of the

[1] *Basilarchia astyanax* (Bas-i-lar′chi-a as-ty′a-nax), or *Limenitis ursula* (Li-men-i′tis ur′su-la), of the family Nymphalidæ, the "Four-footed butterflies."

most grotesque and fantastic in nature. It must be seen to have all its grotesqueness of color and form appreciated (Fig. 84).

We cannot help being interested in it, especially as its movements are as strange and fantastic as its color and form. There must be meaning in it all. We must keep in mind that structures and habits to-day are the results of ages of struggle for self-preservation, and although we cannot understand all, because we do not know all conditions and environments of these past ages, yet we can interpret many things, which otherwise would be meaningless, into marvelous adaptations for the life of the individual and for the continuance of the race. The Sovereigns form a group of butterflies whose life histories give us many chances for interpretation of this sort.[1]

One position maintained for hours by this larva on the brown stems of its food plant is shown in Fig. 84. Surely it looks more like a rough piece of bark than like a live caterpillar. The anterior end is arched and the head is far under, support being given by the long tubercles on the second segment; the posterior end is held aloft. There are other positions taken which are quite as ridiculous.

The caterpillar when nearly full-grown always rests on the brown stems and twigs rather than on the green leaves of its food plant, and must be greatly protected by the habit. It spins much silk wherever it goes, being very helpless without these woven pathways. It moves very slowly, sometimes with slight jerks forward and

[1] Read The Struggle for Existence in the Genus Basilarchia, Scudder's "Frail Children of the Air." pp. 22–38.

backward. This caterpillar surely seems strange and startling enough to frighten away almost any enemy.

FIG. 85. — Larva of the Red-spotted Purple butterfly, in position for change to chrysalis.

The caterpillar, when ready for the change to chrysalis, catches its posterior prolegs in a thickened carpet of silk and hangs suspended with the ventral part of the body curved upward (Fig. 85). After about twenty-four hours in this position in preparation for the moult, the colors are greatly paled, and we can see by holding the caterpillar up before the light that the chrysalis within is separated from the caterpillar skin. This skin is left empty in the regions of the prolegs and tubercles, and especially at the posterior end, where the slender cremaster of the chrysalis lacks much of filling the caterpillar skin.

FIG. 86. — Chrysalis of the Red-spotted Purple, attached to cherry twig. Caterpillar skin not detached.

At last the skin splits back of the head, is moulted, and the chrysalis is revealed. This stage continues about ten days. (Refer to Figs. 15–19 to see the same process in the Monarch.)

The undeveloped butterfly parts can very easily be seen, but certainly this chrysalis (Fig. 86) is about as ugly looking as was the caterpillar. It has the same coloring and much the same arrangement of colors, but looks wet, as though just dipped into oil or varnish. It is curiously shaped, rounded, not angular, and has a great projection on the back of the thorax, which seems to be comparable to nothing but a Roman nose.

The chrysalis is usually a rather active one, the motion being limited to the abdominal segments. When it is disturbed in any way whatever, the chrysalis swings vigorously and rapidly, and the Roman nose is bumped again and again against the support. It is well that the soft parts of the butterfly do not extend out into this projection, which must protect the butterfly greatly, swung loosely as it is from its posterior end, so that it is at the mercy of every gust of wind. Both caterpillar and chrysalis bear close resemblance to the excrement of birds, and must be greatly protected thereby.

However curious and interesting we find the full-grown caterpillar, it cannot compare with the young caterpillar, which we are always tempted to call clever.

The minute green egg is laid on the upper side at the extreme tip of the pointed cherry or other leaf, and is protected not only by its unusual position (since ants, spiders, and ichneumons are likely to search on the broad parts of the leaf), but also by the fact that it is closely covered with slender, flexible filaments, such as are often found on leaves themselves, or on some abnormal growths of leaves. Notwithstanding all this, there is evidence to show that they are destroyed in large numbers, the largest destruction being brought about probably by extremely

minute ichneumons, of whose size we can get some idea when we consider that a whole brood of them, twenty or more, can be nourished and developed in one minute butterfly egg.

At the close of about ten days, if no enemy has intruded, the little caterpillar comes forth, eats its eggshell according to the usual caterpillar instinct, and then begins

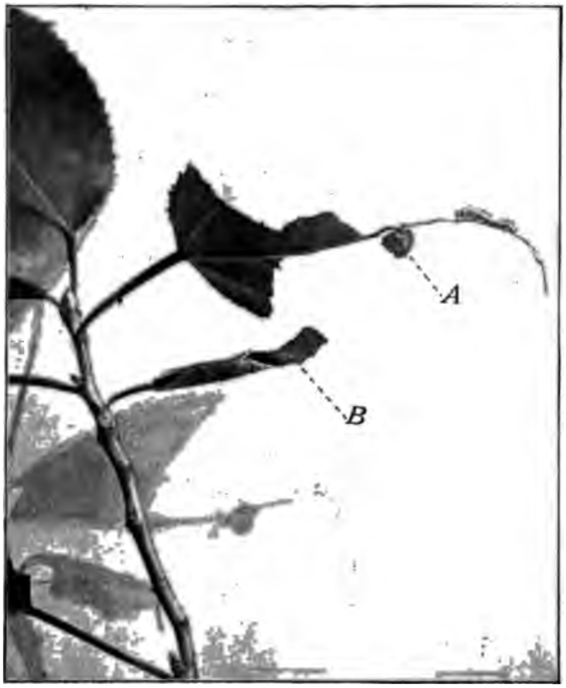


FIG. 87.—Young larvæ of the Viceroy on midrib of eaten leaf. Swinging packet (*A*) in its ordinary position. Leaf below formed into hibernaculum (*B*) by some other Viceroy larva. Photographed from life.

to eat the leaf at its feet. It devours the leaf at the right and left of the midrib, and then retires to the denuded midrib, head out, to rest. Again it eats the leaf at each side and retires to the end of the midrib to rest. This habit is maintained until the caterpillar is about half grown.

Silk is spun on every trip out and back, so the midrib is strengthened and usually kept from curling. The little slender brown caterpillar is motionless on the brown midrib. This must be a protective instinct (Fig. 87).

But this is not all. What means this brown ball swinging from the midrib next the edge of the eaten leaf (*A* in Fig. 87)?

The caterpillar has the habit of forming a packet of broken bits of leaf and silk, and fastening it loosely to the midrib as far back from its resting place on the end of the midrib as possible. The meaning must be protection. The packet is moved by every breath of wind; perhaps by attracting attention to this moving object, the caterpillar out on the end of its midrib escapes attention. There is possibly some meaning here that has not been explained.

We have yet to see the most curious habit of all. After the second, sometimes after the first, moult the caterpillars of the fall brood prepare winter quarters for themselves, for these tiny atoms of life must exist through the winter. The remnant near the stem of an eaten leaf is used, or sometimes a leaf is cut down to the proper size (Fig. 83), the edges are drawn together, the resulting slender cylindrical nest is lined with many layers of silk, and is fastened most securely to the main stem after the fashion of the Promethea cocoon (Fig. 97). A piece of the leaf or a projecting midrib is always left as a front porch for this little winter house (Fig. 89).

FIG. 88. — Winter house of Viceroy cut open to show caterpillar within.

The caterpillar inspects its new quarters, walks in and out again, out to the branch and back, wanders around it for perhaps a day, and finally retires head first just as far into the nest as possible. There it sleeps through all the long, cold winter (Fig. 88), and is alive and hearty when it backs out into the world again in the spring, just as soon as the buds begin to open so it can find food. We may find these winter houses (Fig. 89)

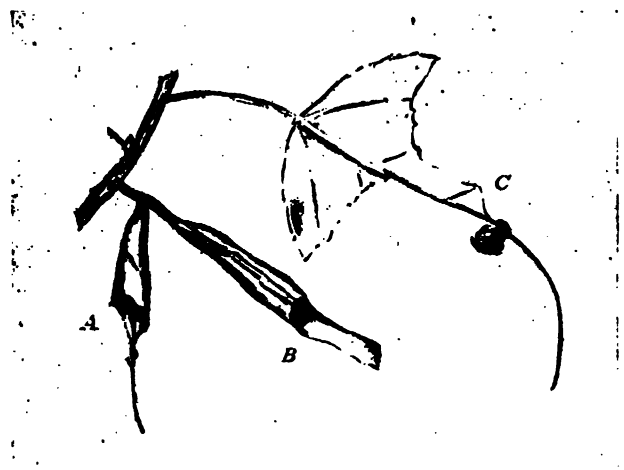


Fig. 89. — Leaf (*C*) eaten by a Viceroy caterpillar, and two hibernacula (*B* and *A*). *A* was made by the caterpillar of Fig. 87, from a detached piece of leaf.

on the trees in spring, but we shall have to look sharply, for they bear a close resemblance to the brown buds of the tree.

The Red-spotted Purple fresh from the chrysalis is a marvel in richness and beauty of coloring. The upper surface of the wings is velvety black, tinged with blue, and there are three rows of blue spots forming wide borders on the posterior wings (Fig. 90). The under surface is brown, banded with black at the margins; there

are two orange-red spots at the base of each fore wing, and four at the base of each hind wing. The butterfly has an expanse of three and one-quarter inches.

The Viceroy (Fig. 28), which has already been described as a successful mimic of the Monarch, is the most common and most widely distributed butterfly of the group of

Fig. 90. The Red-spotted Purple. Velvety black tinged with blue, with three rows of blue spots forming wide borders on the hind wings. Photographed from mounted specimen.

Sovereigns in the United States; the Red-spotted Purple (Fig. 90) is probably next in abundance and distribution. It is fairly common over the eastern United States and the Mississippi Valley to about the forty-third parallel.

We shall find this butterfly through the summer and in September along roadsides and the borders of woods, and sometimes along shaded paths in woods. It is especially attracted by decaying fruit and other organic matter.

The Banded Purple[1] is a butterfly very nearly allied to the Red-spotted Purple. It is found through the northern part of the United States and in Canada. It can be recognized by broad bands of white, one across each wing. In that part of the country (southern Wisconsin and eastward to the Atlantic coast) where the habitats of these two butterflies — the Banded Purple at the north, and the Red-spotted Purple at the south — overlap each other, there are butterflies that have the characteristic markings of both. These butterflies vary greatly: there are some that show but little difference from the Red-spotted Purple; others with narrow white lines across the wings; and still others differing only slightly from the northern broad-banded forms.

[1] ***Basilarchia arthemis*** (Bas-i-lar'chia ar'the-mis), or *Limenitis arthemis*.

THE WHITE AND THE YELLOW

THE CABBAGE BUTTERFLY
THE CLOUDED SULPHUR

"Whaur the bee swings ower the white-clovery sod,
And the butterfly flits like a stray thoucht o' God."

FIG. 91. — The common Clover butterfly (the Clouded Sulphur). Yellow with black markings. Resting after refreshment. Natural size. Photographed from life.

THE WHITE AND THE YELLOW

OUR white and yellow butterflies are so common that surely there is no one who is not familiar with them. They are part of the landscape everywhere, in fields and roads and gardens, and they add much to its beauty.

> "At noon the roads all flutter
> With yellow butterflies"

and there are

> ". . . little white butterflies,
> two and two
> In eddies of odorous air."

There are many kinds of white and yellow butterflies. Their common names describe them. The Gray-veined White is common in Canada and the northern part of the United States; the Checkered White is commonly known over nearly the whole of the United States. These are both of medium size. Their larvæ feed on plants of the mustard family. The yellow butterflies are still more numerous. There are the Black-bordered Yellow, the Orange Sulphur, the Little Sulphur, the Cloudless Sulphur, and many others — the majority of them southern and western forms. Most of their larvæ feed on cassia or clover. The white and yellow butterflies, companions of the buttercups and dandelions, fly through all the summer season, but they are in swarms in goldenrod time. They can be found in scattered numbers until November, sitting with late bees at feasts spread for them by the dandelions.

Our common white butterfly is the CABBAGE butterfly,[1] so called because its larvæ feed on cabbage and have made

FIG. 92. — Cocoons of parasites of the Cabbage butterfly.

themselves rather notorious over the country by the amount of damage they have done. Their parasitic enemies have now come to the front, and have increased so in numbers that they are restoring the balance in nature. From one hundred and fifty Cabbage butterfly caterpillars gathered in the fall of 1899, only sixteen chrysalides were obtained. From the others thousands of minute parasites came out one by one through the skin of the caterpillars and made their tiny cocoons in clusters on some near object (Fig. 92). Truly there is a struggle among races, and the balance in nature is well kept.

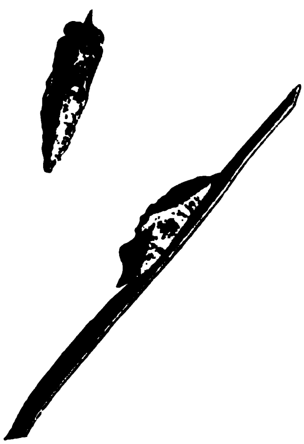


FIG. 93. — Cabbage butterfly chrysalides, distinguished by single point at head end. Supported by girdle of silk in addition to the fastening at the posterior end. Photograph.

[1] *Pieris rapæ* (Pi'er-is ra'pæ), of the family Pieridæ (Pi-er'i-dæ), Comstock's "Manual for the Study of Insects," p. 381.

The eggs from which these caterpillars come are very beautiful, flask-shaped and pale yellow, with about twelve vertical ribs. They are laid on the undersides of the cabbage leaves.

The larva is green, covered with very fine white hairs; it has a narrow yellowish dorsal band and an interrupted line of the same color on each side.

FIG. 94. — The Cabbage butterfly in resting position. Upper surface, white with black markings. Under surface of wings washed with yellow. Natural size. Photographed from life.

The chrysalides (Fig. 93) are slender and delicate in appearance; they are angular, with a slender pointed projection at the head end; they are attached at the posterior end and girt about by a loop of silk. The process of chrysalis formation is the same as in Turnus (Figs. 52–55). The chrysalis is the winter state of the butterfly, but in the summer broods this state continues only ten or twelve days.

The butterflies are of medium size (Fig. 94), white above, washed with yellow below; the fore wings are black-tipped. In the female there are two black spots on each fore wing, in the male but one. In both male and female there is a black spot on the front part of each hind wing. There is much variation in the amount of yellow on the wings, and in the intensity of the black markings.

These butterflies are probably three-brooded in temperate regions. They are very fond of the nectar of flowers and do a vast amount of work for the flowers, carrying the

pollen from one to another. They are thought to be most attracted by flowers of their own color, and when such is the case, of course their color becomes protective.

The history[1] of this butterfly since its first introduction into our country in 1860 is truly interesting. From different starting points, Quebec, New York, Charleston, Chicago, etc., it has spread rapidly in waves that have met and mingled, until it occupies the whole extent of the United States from coast to coast. It came from Europe to a new country where its food plants — cabbage, turnip, and other members of the mustard family — were very common, and it left behind it the parasitic enemies peculiar to it; and so for years it thrived. As has been said, the balance of nature is now rapidly being restored by the tremendous increase of the ichneumon fly which is parasitic upon this caterpillar.

Fig. 95. — Cocoons of parasites of Clover butterfly.

Our most common yellow butterfly in the United States is the CLOUDED SULPHUR or CLOVER butterfly[2] (Fig. 91). The upper surface of its wings is yellow, bordered with black; each fore wing bears a conspicuous black spot,

[1] Read Scudder's "Everyday Butterflies," pp. 18–24.

[2] *Colias philodice* (Co'li-as phi-lod'i-ce), or *Eurymus philodice* (Eu'ry-mus phi-lod'i-ce).

each hind wing has a spot of orange. In the female the border of the fore wing is broader and contains a row of yellow spots. The female butterfly is sometimes white instead of yellow, showing a very marked case of dimorphism.

The butterflies are common from early May until the middle of October. They are very familiar sights indeed, fluttering and zigzagging over the flowers of the field or meadow, or collected in groups around small puddles of water along country roads.

The caterpillar is green and slender, and feeds on clover. It has many parasitic enemies[1] which desert it usually before the chrysalis stage, and make their small cocoons on a clover stem or a grass blade near (Fig. 95). These clusters of yellow or white cocoons are somewhat conspicuous in meadows and along roadsides in September and October; probably we all thought them clusters of eggs of some sort before we examined them closely. Each little cocoon opens by means of a lid at the top, and the minute ichneumon fly bobs up like a jack-in-the-box, crawls out, dries its wings and flies away in search of its mates and other yellow butterfly caterpillars.

The Clouded Sulphur eggs are placed singly on the upper surfaces of clover leaves. They are spindle-shaped, placed on end. They change color several times during their growth, from yellowish green to shades of salmon and red. The chrysalis is very like that of the Cabbage butterfly.

[1] Read Those Puzzling Cocoon Clusters, Gibson's "Sharp Eyes," pp. 199–202.

Part II

MOTHS

Entomology extends the limits of being in new directions, so that I walk in nature with a sense of greater space and freedom. It suggests, besides, that the universe is not rough-hewn, but perfect in its details. Nature will bear the closest inspection; she invites us to lay our eye level with the smallest leaf and take an insect view of its plane.

THOREAU

THE PROMETHEA MOTH

FIG. 96. — Cynthia moth (nearly related to Promethea). Greenish brown with markings as shown. Tufts of white hairs on the abdomen. Natural size. Photographed from life. (Refer to p. 142.)

THE PROMETHEA MOTH[1]

LATE in fall and winter we may find brown cocoons (Fig. 97) containing the chrysalides of the Promethea moth swinging from the branches of the wild cherry, the sassafras, the buttonwood, and the ash. These cocoons are made within leaves which are firmly fastened to branches, so that the cocoons do not fall, but ride securely through all the winter storms. In fact, we may find old cocoons which have endured the storms of several winters.

FIG. 97. — Cocoon of Promethea, made within a leaf and fastened securely to a branch of sassafras. Natural size. Photographed from life.

They are conspicuous and easily found — if we have sharp eyes. Let us look for them and collect them during our fall and winter walks,[2] that we may have them for spring study; besides, it adds

[1] *Callosamia promethea* (Cal-lo-sa'mi-a pro-me'the-a), of the family of Giant Silkworms (Saturni'idæ).

[2] Read The Cocoon Harvest. Gibson's "Sharp Eyes," pp. 253-257.

zest to a walk to have some aim in view. In May and June we shall be well repaid for the time spent in

FIG. 97a. — Promethea moth (male). Wings black with brown borders. ½ natural size. Photographed from life.

searching for them by the sight of the moths fresh and vigorous from their long winter sleep.

But it is more interesting still to find the caterpillars and watch them spin their cocoons, keeping the cocoons to see what comes out from them. Thus we shall have the whole life history. We can find the caterpillars in September and October feeding on leaves of the trees on which the cocoons are to be found later.

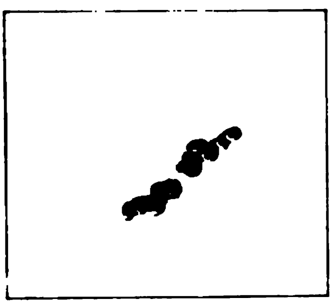


FIG. 98. Eggs of Promethea. Natural size. Photograph.

The eggs (Fig. 98) are laid in clusters on the leaves of these trees in late May and June and again in August and September; that is, there are two broods each year. There are sometimes only five or six

FIG. 99. — Promethea caterpillars on wild-cherry leaf twelve hours after leaving eggs. Caterpillars are banded with yellow and black. Slightly enlarged. Photographed from life.

eggs in a cluster, but more often twenty or thirty are laid together. The eggs are small, light-brown, oval bodies, somewhat flattened above and below, and sometimes with a darkened depression in the center of the top. Each of the young caterpillars in the little colony eats its way out at one end of the egg (refer to Figs. 134 and 157 to see same process in Cecropia and Polyphemus); then all take up position on the underside of a tender leaf. They are small, not more than one-fifth inch long, with very large heads. They are banded with yellow and black, the yellow predominating. They stay close together on the underside of the leaf, all in a row, with heads out, and eat the leaf. In

FIG. 100. — Promethea caterpillars three days after leaving eggs. Banded with black and yellow. (Black caterpillars are Cecropias just out of eggs.) Slightly enlarged. Photographed from life.

a soldier-like line they begin to eat the leaf at its margin; as they eat it they retreat in a line, heads close together, bodies side by side.

At the end of one day their bodies are perceptibly larger, so that their heads do not seem so large; and after three days of alternate eating and resting, the head is small in comparison with the body (Fig. 100). The Promethea caterpillars are social in their habits, living happily side by side until they have attained considerable size. As a rule they rest during the day and feed at night while they are young, an evident means of protection.

FIG. 101.—Promethea after second moult. Light bluish green, with black and yellow tubercles. 1⅓ diameters. Photographed from life.

Caterpillars which came from eggs June 9 passed through the first moult June 14, retaining the yellow and black dress. The second moult was June 18, after which they were greatly increased in size and were clear blue-green in color, with longitudinal rows of black tubercles, and five

larger yellow tubercles, four at the anterior end and one at the posterior. All tubercles were slightly branched at the top and extended into short spines (Fig. 101). On June 22 the third moult followed and the caterpillars appeared in a dress more like the adult — greenish blue, with all the black tubercles smaller and without

FIG. 102. — Promethea caterpillar after the third moult. Greenish blue, with orange tubercles near the head. × 1½. Photographed from life.

branches or spines; the five large tubercles were much increased in size and cylindrical in form, the four near the head bright orange in color, the one near the posterior end still yellow (Fig. 102).

On June 27 the caterpillars passed through the fourth moult, and if we were to judge from appearances we should say that if the caterpillars that came from the

eggs June 9 (the little black and yellow banded creatures) were Promethea caterpillars, surely these could not be. But we have watched; we have seen the black and yellow banded one moult its skin and become green with yellow tubercles, the green one change to blue with orange tubercles, and finally the blue is even more blue and the tubercles are red.

Let us watch the caterpillars during this fourth moult and see if we can find out what really takes place.

The skin is shed because it is made of chitin, a horny substance which neither grows nor stretches to allow for the rapid growth of the caterpillar.

The caterpillar spins a carpet of silk, walking back and forth over a portion of the leaf. It moves its head alternately to right and left, back and forth, and the thread of silk issues from the spinneret below the mandibles and glues itself to the leaf. The caterpillar rests on this carpet for twelve hours or more; it is perfectly inactive; we may think it dead.

If removed from its support, it is helpless and cannot even walk. If we look at it closely, we see the cause of its helplessness. The outer coat of chitin is separated from the creature within, and the caterpillar is as helpless as any other creature would be if fastened securely within a bag which was much too small for it.

If we look still more closely, we see that the caterpillar seems to have two heads — a small dark one, and a large light-colored one back of it. The truth is the head has been drawn backwards out of the head skin and shows plainly through the skin of the first segment of the body. (Refer to Figs. 13 and 14 to see same in Monarch.) This puts extra strain upon the chitin of the first segment,

ıich is naturally a weak place. As we watch, the skin this weakened place splits and shrinks backward with ry little effort on the caterpillar's part. Back it shrinks er the true legs, and over the orange tubercles, on towards

FIG. 103. — Promethea moulting skin. Removing the old head skin. × 1½.

e prolegs, and over the first pair. But the caterpillar having difficulty with its old head skin, which is still stened over its mouth-parts (Fig. 103).

The head is rubbed alternately back and forth against e support, as a bird rubs its bill against a perch; the

FIG. 104. — Moulted! Head and body skins shed separately. × 1½.

ıe legs assist, being used as a cat uses its paws to wash face; finally the cap falls. Now the remaining prolegs ıd the posterior end of the body are released from their

imprisonment in the old skin (Fig. 104), and the caterpillar takes a step forward. It is free! It is much larger: the old skin must have been much too tight. This old skin, perfect but very much shrunken and wrinkled, remains attached to the carpet of silk (Fig. 105).

It is fortunate that we did not push the caterpillar off its silken carpet; it could not have spun another, and the moulting is quite impossible unless the skin is securely fastened by means of the hooks of the prolegs, so that the caterpillar can walk out of it. If the caterpillar is removed from the support, the moult may proceed until the skin is

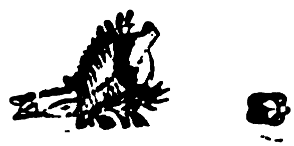


FIG. 105. — Cast-off clothing.

off the four pairs of prolegs; but the caterpillar will be powerless to extricate its posterior part. Instead, the skin will remain there, become stiff and dry, and the caterpillar will be killed by it.

In about an hour the caterpillar has a new, hard coat of chitin and all its bright colors, and is ready to pursue again its ordinary daily life of eating and resting. The caterpillar is now in its adult dress, and it really has considerable beauty.

It is something over two inches long and is very smooth. It is clear light blue in color, with a yellow head. It has six longitudinal rows of tubercles which are shining black, but scarcely elevated above the surface of the

body. The black tubercles are surrounded by circles of dark blue. The legs and the last segment of the body are yellowish green. On the second and third segments are four large tubercles, cylindrical and of rich red color; while on the eleventh segment is a similar one, yellowish in color.

We find exactly the same fundamental structure in Promethea as in the Milkweed caterpillars and others: twelve segments in addition to the head; on each of the first three segments a pair of "true" legs; five pairs of prolegs, which are merely caterpillar structures, one pair for each of the sixth, seventh, eighth, ninth, and twelfth segments; nine pairs of spiracles for breathing, one pair on the sides of each segment except the second, third, and twelfth; simple eyes on the sides of the head; strong mandibles for eating the food plant; a spinneret below the mandibles.

And not only are there the same parts in Promethea as in other caterpillars, but each part has the same adaptation for its work. The true legs hold the leaf as the mandibles cut it out in retreating curves (Fig. 102); the caterpillar walks boldly to the midrib of the underside of a leaf and rests there with its weight hanging down, because the tiny hooks on the prolegs are so many and strong; and so on. The Promethea is protected by its coloring, but more by its perfect immobility. Never was any other caterpillar so quiet; "lie low" is the law. The caterpillars seem to move very little, and that little very slowly.

In three weeks or a month after the Promethea caterpillar leaves the egg it is ready for the change to chrysalis, whether it belongs in the spring brood or the fall brood. However, when caterpillars are in captivity, the length of

time before maturity, as well as the time between moults, will be found to vary greatly, depending on the temperature, on the kind of food supplied, and the quantity, and also on the degree of cleanliness of the boxes or glasses in which they are kept.

We always know when the change is near, by the behavior of the caterpillar; it no longer eats, but wanders about the food plant, up and down the branch, out upon the leaves and back, apparently in the most aimless way.

FIG. 106. — Promethea spinning cocoon within a leaf.

But finally a leaf is chosen, and the caterpillar begins spinning silk over its upper surface. When a considerable carpet is spun, the caterpillar walks up the leaf to the stem, always spinning, out the stem to the main branch, still spinning diligently. It continues spinning silk over the leaf stem and around the branch, until the leaf is securely fastened to the branch. Then the caterpillar retreats to the middle of the upper surface again; and by fastening threads of silk on the right side of the leaf and stretching them over to the left side — not fastening them between points of attachment — and by gradually shortening these ropes of silk, the edges of the leaf are curled upwards until they form a roof over the caterpillar.

It is most interesting to watch the spinning of the cocoon. The diligence of the caterpillar is something marvelous. For hours it spins, the head constantly moving back and forth to place

the silk thread advantageously as it comes from the spinneret. For a time the caterpillar gives its attention to the upper part of the framework for the cocoon (Fig. 106). Then it turns about in its small house (here we see the value of the great flexibility of the body) and works busily at the lower part of the cocoon, the posterior end of the caterpillar protruding at the top, and looking like some strange, new creature (Fig. 107).

FIG. 107. — Giving attention to the lower part of the cocoon. (Posterior end of caterpillar protruding.)

A Promethea spinning its cocoon is a very attractive sight, with the green leaf on the outside, the bright blue and red of the caterpillar gleaming through the shining white network of the silk. Of all caterpillars the Promethea is certainly the least repulsive; and no matter how much we are prejudiced against it, we come to realize that it is not only interesting but beautiful, as we watch it spinning about itself this cloak of glistening white.

Finally the cocoon is completed, after twenty-four hours or more of work. We can no longer see the caterpillar through it; we can no longer hear sounds of work within, when we hold the cocoon close to the ear. This cocoon, wrapped in its green leaf, swings from the tree in July as do other leaves, wonderfully protected by its resemblance to other folded leaves which hold no living secret within them. In the fall, brown curled leaves cling to the wild cherry and the sassafras, and if we notice them at all, we think them only brown curled leaves; but the Promethea

moth is sleeping soundly inside. The fact that the cocoon is swung loosely from the branch must protect it from the attacks of birds. A thrust at it with the bill will simply cause it to swing forcibly away ; a bird can get no purchase on it so as to tear it open.

FIG. 108. — Opened cocoon to show conical valve at top. Photograph.

If we examine the completed cocoon, we find it double at the top, with a sort of conical valve-like arrangement, which opens when pressure is brought to bear from within (Figs. 108 and 109). This is evidently to allow the escape of the moth. It is easy to see the method of spinning which produces this valve. In spinning all the other parts of the cocoon, the caterpillar walks about moving its head from side to side in the figure eight ; back and forth the caterpillar goes, around and about, always moving its head from side to side, so that the silk threads overlap again and again to make a firm network. But at this upper part of the cocoon, after the framework of ropes of silk is made and an opening is left at the top, the caterpillar moves its head up to the opening, and back along nearly the same line but a little at one side, up to the opening again and back, up and back, the caterpillar turning completely around, clinging with its prolegs to

the silk framework. Then all the way around it goes again, moving its head continually and rapidly up to the opening and back. By this time, because of the constant inward and downward pull made by the weight of the caterpillar, the opening is quite closed, but of course the cocoon will readily open when pressure is brought

FIG. 109. — Cross-sections of Promethea cocoons, to show valve for the escape of the moth at the top of the cocoon. Photograph.

to bear from within. And so the valve is made and ready for use.

The act of spinning the carpet of silk before the moult, the formation of this valve-like affair for the escape of the moth, and especially the fact that the leaf is securely fastened to the branch before the cocoon is made in it, seem to point to intelligence in the caterpillar. We are filled with wonder when we consider that these acts are race habits: that they have come about through ages of

struggle for existence, in which those creatures which did the thing most self-preservative survived, and sent on the self-protective act as an inheritance to their offspring.

That the fastening of the cocoon to the branch is instinct rather than intelligence, is interestingly shown by the fact that in the corner of a box or in a glass the caterpillar will spin the same long strip of silk out from the cocoon — where of course it is of no possible service

Fig. 110. — Cocoon made in a box, photographed to show long strip out from cocoon. This strip is made as strong as though it served its usual purpose of fastening a leaf to a branch.

— and make it just as strong as though it were over the stem of the leaf and around the branch (Fig. 1[illegible]).

The caterpillar rests after it is tightly shut in its cocoon, and after all the liquid silk from its two silk glands has been sent through the spinneret in yards and yards of gleaming thread. The period of rest varies, but usually lasts at least two days. If we cut open the cocoon at the end of two days and examine the caterpillar, it seems much shrunken, and gives evidence of life by a few feeble movements only. If, instead, we wait several days

and then cut open the cocoon, we no longer find a caterpillar but a brown chrysalis, and at its posterior end the shriveled caterpillar skin (Fig. 111). The caterpillar skin has split in the front segment back of the head and has been moulted. But as the skin retreats it is not a caterpillar that is revealed but a chrysalis, broad at the anterior end, slender and tapering to a point at the posterior end. This is the fifth and last moult of the caterpillar.

Why was not the carpet of silk needed as before? We do not find the moulted skin fastened in any way; it lies loosely at the pointed end of the chrysalis. We do not have to look far for the explanation. The shrinking skin could easily slip off the tapering end of this chrysalis; whereas a caterpillar has a large posterior part with a great pair of prolegs at the end, which require force to remove them from the skin.

FIG. 111. — Cocoon cut open to show chrysalis and moulted caterpillar skin. Photographed from life.

The lining of the cocoon is shining and smooth, its walls

are thick, and the opening at the top is immediately over the head of the sleeping chrysalis (Fig. 111). It seems made in the best way for protection from sudden change of temperature and from rain, as well as from birds and other enemies, and for the final easy escape of the moth. The chrysalis (Figs. 112 and 113) is brown and smooth, and is covered by hard chitin; however, the surface of a moth chrysalis is never as hard as that of a butterfly chrysalis, since one is protected by the cocoon while the other is not. If we examine the chrysalis closely we see the segments and spiracles of the abdomen, the wings wrapped from back to front, the extremely short proboscis and the large, feather-like antennæ (Fig. 114). The legs are not to be seen; they lie under the antennæ. The chrysalis gives evidence of life in a feeble movement of the abdominal part.

FIG. 112. — Promethea chrysalis. Front view. Male. Natural size. Photographed from life.

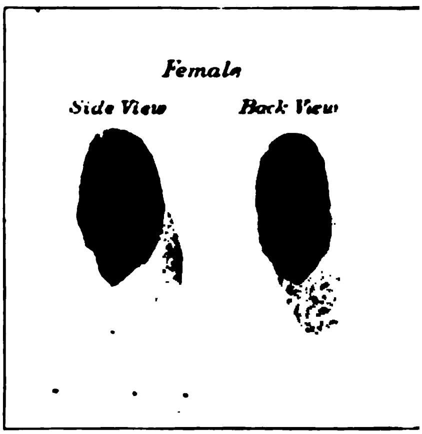


FIG. 113. — Side and back views of Promethea chrysalis. Female. Natural size. Photographed from life.

The moths of the June and July brood remain in the cocoons between three and four weeks, those of the September brood use

the cocoon as a winter protection. Then the moths come forth! Can you remember your sensation the first time you ever saw this resurrection? No wonder these creatures were taken as symbols of immortality by the ancients! Their extreme freshness and beauty of coloring and form, their sudden awakening to intense vigor

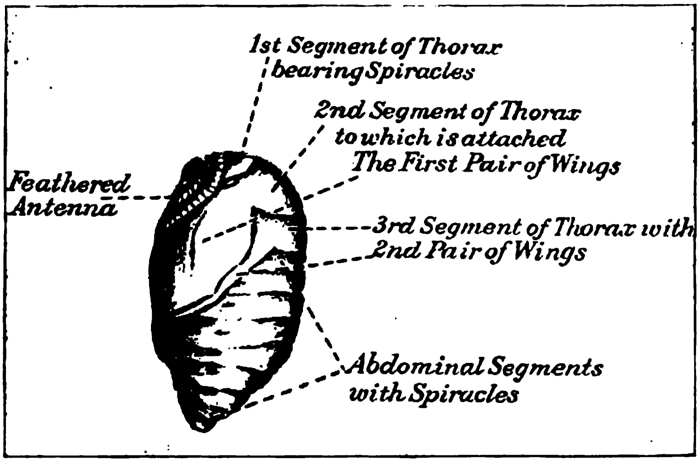


FIG. 114. — Drawing of Promethea chrysalis to show various parts of undeveloped moth.

and life after the long sleep in the chrysalis state, thrill us in spite of ourselves.

The Promethea moth (Fig. 115) usually comes from the cocoon in the forenoon, and is ready for flight by four or five in the afternoon. The moths of the Giant Silk-worm group to which this belongs fly at night, but Promethea is an exception to the rule; it is a day-flier like the butterflies.

The cocoons are usually made near the base of a tree or shrub, the caterpillars descending from the high branches when they are ready to spin. So when the moth comes

from its cocoon, wet and heavy, and with small unexpanded wings, its first instinct is to climb to some protected place among the leaves at the top of the tree. And so it climbs awkwardly enough until the end of some high branch is reached, where it clings and rests, with its whole weight hanging heavily from the support (Fig. 116). (Refer to

FIG. 115. — Female Promethea moth. Reddish-brown wings, crossed midway by zigzag line of white, and bordered with light brown. Natural size. Photographed from life. (The wings of the male are well-nigh black, but show the same light-brown borders.)

Fig. 151 to see Polyphemus in such resting position.) The expansion of the wings has already begun; it now continues rapidly. Blood is pumped from the large body out into them, the body gradually grows smaller, and the wings visibly expand. In an hour or an hour and a half the moth seems to be in its full strength; but it does not attempt flight until several hours later.

The moth is very like the butterfly. It has three divisions of the body: head, thorax corresponding to the first three segments of the caterpillar, and abdomen corresponding to the other nine segments and bearing spiracles for breathing. (Refer to Fig. 9.) There are three pairs of jointed legs attached to the underside, and two pairs of wings on the upper side of the thorax. The head bears two eyes and a pair of antennæ. The mouth-parts are very much reduced, in fact, in Promethea, the proboscis is so short that it is practically useless; this moth never takes food, and so is very short-lived.

FIG. 116. — Promethea just out of cocoon. Photographed from life.

When we note that the antennæ are not slender, with knobs at the ends, but are distinctly feather-like (Fig. 117), we have found the greatest visible distinction between this moth and butterflies. The body and legs are very hairy; the head is very much depressed, scarcely extending beyond the thorax.

The male moth is so different from the female that it is usually taken for a distinct species. The female wings are reddish brown above and below, crossed midway by a zigzag line of white bordered on the inside by black (Fig. 115). Each wing is light brown at its outer margin.

and has between the transverse band of white an point of attachment to the body an angular light which varies in prominence in different individ There is a conspicuous eye-like spot near the tip of fore wing. The male wings show the same light-b borders, the same eye-like spots at the tips of the wings, but the whole upper surface, exclusive of the clear black (Fig. on p. 120). The transverse zigzag show very indistinctly, and the angular spots do

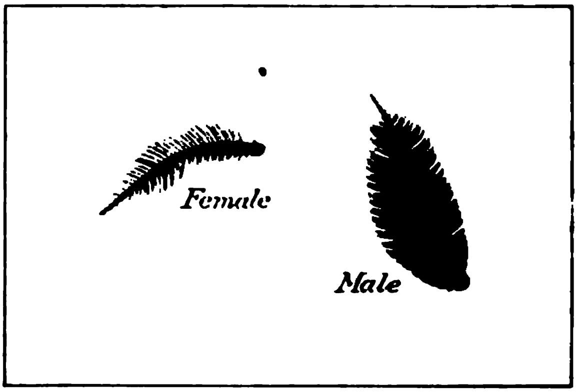


FIG. 117. — Antennæ of Promethea moths. × 2½. Photograph.

appear at all. The under-wing surface resembles female more nearly, but is much darker in general The fore wings of the male are much more sickle-sl at their tips than are those of the female.

This Promethea is the most common of our (Silkworm moths. Though the adult never at the size nor the beauty of coloring of some othe the group, all stages of the development are interesting; and because of this and the abundan material everywhere, it is one of the very best study.

The sense of smell (as in the butterfly) is lodged in the antennæ. This is the creature's keenest sense, and serves to attract it to the food plant for its young and to its mates. If we have a female and wish other Prometheas, we may attract many by exposing the female out of doors in a net of some sort.[1] The black moths will flock about the net and can be picked off with the fingers.

FIG. 118. — Promethea depositing eggs. Photographed from life.

Within a day or two after the female moth leaves the cocoon it begins to deposit eggs. The abdomen is curved about the support, and the eggs are placed on the side opposite that to which the moth is clinging (Fig. 118). If the eggs are fertile, they remain plump and rounded; if not, after a few days the upper surface becomes concave.

There is little danger that Promethea caterpillars will become a great pest to man, although they feed on a

[1] Read Denton's "Moths and Butterflies," p. 100. Bradlee Whidden.

very large number of fruit and forest trees; the only wonder is that they are not killed out altogether, so powerful and so many are their parasitic enemies. We may gather one hundred or more cocoons by searching the wild cherry and ash trees in the spring, but we are likely to obtain very few moths from our large supply of cocoons. Let us open one. The whole space is filled

Fig. 119. — Pupa of ichneumon fly in its cocoon within the cocoon of the Promethea moth.

with a second brown cocoon; there is just a fragment of the caterpillar skin at one end. In this cocoon within a cocoon lies motionless the pupa of an ichneumon fly (Fig. 119). It has developed from an egg deposited in the Promethea caterpillar the summer before at the expense of the Promethea, and, when quite ready for the change to the adult form, will throw open the round door at the top of its own cocoon (Fig. 120), push its way through the opening at the top of the Promethea cocoon, and

appear an orange-brown, wasp-like creature with extremely long antennæ (Fig. 121). Its strong instinct is to find Promethea caterpillars in which to lay its eggs, so that when these eggs hatch, the small helpless larvæ may have abundant food. When the egg is laid, all is well for the future ichneumon; but the fate of the Promethea moth is sealed. The caterpillar usually lives long enough to spin its cocoon (an added protection to the ichneumon for the winter) and is then totally destroyed by the parasite.

FIG. 120. — Cocoon of Promethea cut open to show cocoon within from which ichneumon fly has escaped through round opening at the top.

If we open a second cocoon we are likely to find it packed closely with small cocoons containing ichneumons, a second species parasitic on Promethea (Fig. 122).

Did we say that there is little danger that Promethea caterpillars should ever become a pest? It is always possible, for the following reason. If the parasites increase too rapidly, they may kill out so large a proportion of the caterpillars.

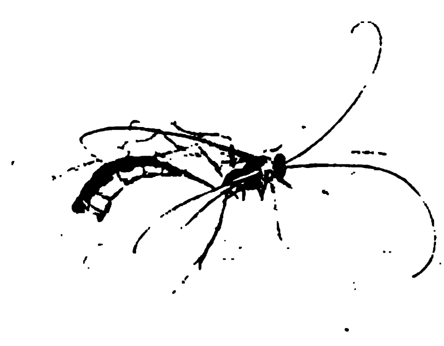


FIG. 121. — Ichneumon from Promethea cocoon (Fig. 120).

their food supply, that this species of parasite must take the consequences and be starved out of existence. In this case, if the caterpillars breed rapidly and are well protected from birds and other enemies, they may so increase as to become a pest before their parasites can come to the front again. This is usually the explanation of the periodic appearances of cankerworms and army worms.

Fig. 122. – Cocoon of Promethea cut lengthwise to show small cocoons of parasites within. The parasite in pupa and adult forms. Photographed from life.

The Cynthia moth,[1] very nearly related to Promethea, is common in the vicinity of New York and Philadelphia. It is an Asiatic form and feeds on the ailanthus, or "tree of heaven." The cocoons can scarcely be distinguished from those of Promethea, but the moth is larger and differently colored (Fig. 96). The moth has tufts of white hairs on the abdomen, and by this characteristic can be distinguished from our native moths of this family.

[1] *Philosamia cynthia* (Phil-o-sa'mi-a cyn'thi-a).

THE BULL'S-EYE, OR IO MOTH

FIG. 123. — Female Io moth in resting position. Natural size. Photographed from life.

THE BULL'S-EYE MOTH[1]

The Bull's-eye moth, or Io, is the smallest of the Giant Silkworm group; but it is most beautifully colored. It is one of the most common over a large part of the United States, and is very interesting in its development.

Fig. 124. — The Bull's-eye, or Io, moth, female. Fore wings purplish brown with inconspicuous markings of dull yellow. Hind wings brilliant with shades of red, yellow, black and blue. Natural size. Photographed from life.

The female measures about three and one-half inches. The fore wings are dull purplish brown, with inconspicuous markings (Fig. 124); the hind wings are much more brightly colored, with a great eye-like spot in the center of each —

[1] ***Saturnia io*** (Sa-tur'ni-a i'o), or *Automeris io* (Au-tom'er-is i'o), of the **Giant Silkworm group of moths.**

of course, the origin of its name. The body and the wings near the body are profusely covered with long silky

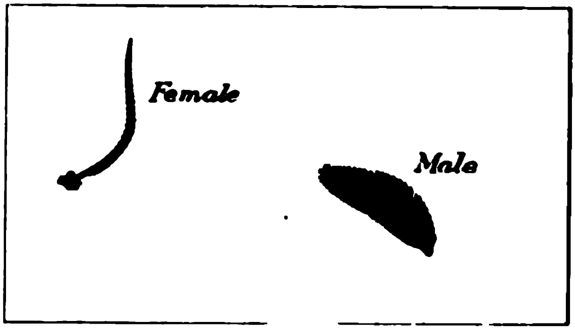


FIG. 125. — Antennæ of Io moths. × 2½. Photograph.

hairs, helping to make the moth a very handsome one. When it is resting, the wings are folded roof-wise over the body (Fig. 123), the bright hind wings being covered by the duller fore wings so that the moth blends perfectly with its surroundings, a brown tree trunk or a dull fence board, and is thus protected.

FIG. 126. — Clusters of Io eggs. Each is cream-colored, with a dark blue spot at its top. × 2. Photograph.

The male is smaller, some three inches in expanse of wing, and more brightly colored; but it would always be recognized by its general resemblance to the female. It is bright yellow, the hind wings brilliant with shades of red, black, blue, and yellow. The male can always be distinguished from the female by its broad feathery antennæ (Fig. 125).

The moths come from the cocoons in June, and soon after the eggs are laid on the undersides of leaves of

the various food plants. We may expect to find them on almost all kinds of plants; on corn, on cherry and shad bush, hop, bayberry and apple, elm, oak, willow, etc. The eggs are laid in clusters of from twenty to eighty or more (Fig. 126). Each is cream-colored, shaped like a top, with the small end fastened to the leaf.

A week after the eggs are laid a dark spot appears on the side of each (a transparent place through which the dark caterpillar shows), and a few days later the young caterpillars make their escape by eating through the eggshells.

The little caterpillars, orange-brown in color and covered with minute, branched, black spines, remain huddled about the eggs and gradually devour the shells. To "lie low" is their first instinct.

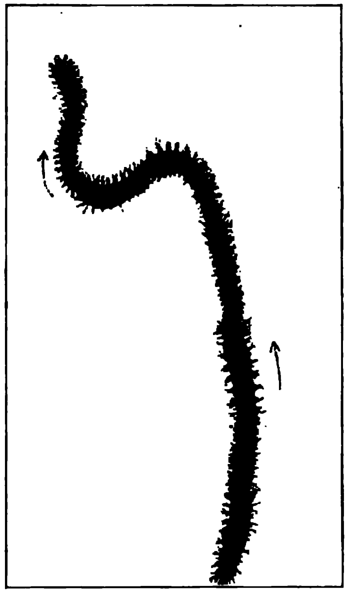


FIG. 127. — Procession of young Io caterpillars. Photographed from life.

When the eggshells are eaten quite down to the leaf, the leaf itself is attacked. All together on the underside of the leaf, with tails in and heads out and bodies curved to fit nicely together, they eat the edges of the leaf, cutting it out in curves. When they are disturbed all draw back together into a compact mass, bodies curved to fit together, heads under and completely concealed by the long, branched spines.

When they travel they do so in company and in regular order. They march in single line, slowly, heads to

tails, with no side movement of individuals (Fig. 127). The leader's head is moved constantly from side to side to place a pathway of silk for the use of itself and its followers. The leader may stop to nibble the leaf, or rest for minutes at a time; the automatons behind show no impatience.

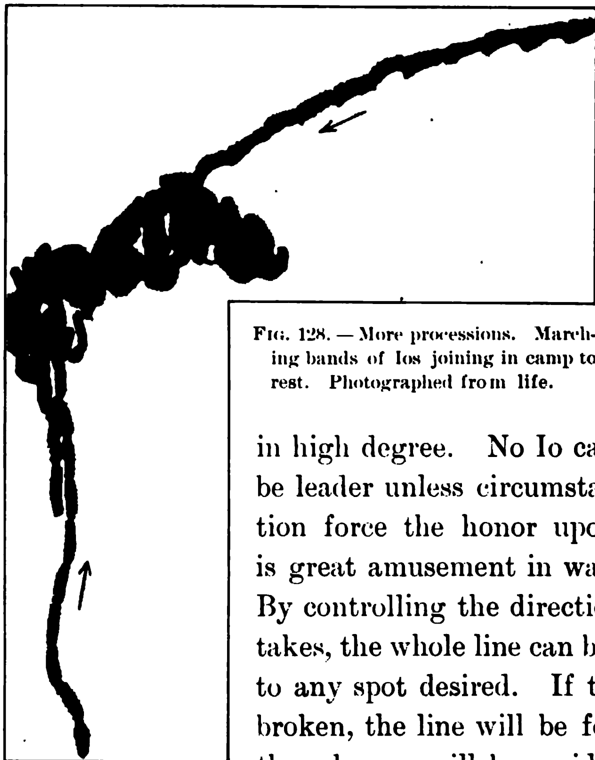


FIG. 128. — More processions. Marching bands of Ios joining in camp to rest. Photographed from life.

They have the following-instinct developed in high degree. No Io caterpillar will be leader unless circumstances of position force the honor upon it. There is great amusement in watching them. By controlling the direction the leader takes, the whole line can be made to go to any spot desired. If the ranks are broken, the line will be formed again, the advance will be rapid and in some disorder at first, but more slow and in due order later. If left alone, they will mount the stem of the food plant, march out under some leaf, and after infinite curves in and out, after forming all sorts of figures, symmetrical and otherwise, they will settle down in a compact mass to rest (Fig. 128) or range themselves along the edge of the leaf to refresh themselves after their journey.

It is amusing also to watch two Io caterpillars meet face to face. Neither will turn out for some time; they stand and interlock their branched spines and, as it were, "rub noses," until finally one gets a little advantage at one side, advances, and passes.

The idea underlying social life in the caterpillar world seems to be the protection given by numbers. On the other hand, in the Io at least, the gregarious habit may be a result rather than a means. The caterpillars are so well protected by their armor of branched, poisonous spines that they have grown bold and do not need to live singly and secrete themselves carefully.

Moulting in the Ios is an interesting process. After several days of eating, here are the little brown fellows all huddled together on the underside of a cherry leaf. They have six longitudinal rows of black branched spines, those nearest the anterior end longest, and projecting forward to cover entirely the little black heads. But look! Each has two heads, a light one back of the little black one. They are moulting, and each curved body is on a carpet of silk. The moult begins. Almost simultaneously the skins of all the caterpillars shrink backward over the anterior parts, and the black caps fall. Then the caterpillars pull their posterior parts out of the old skins, which remain firmly fastened in the carpets of silk. (Refer to Promethea for illustration of process.)

After the moult the caterpillars present a somewhat different appearance. They have the same bright orange-brown dress, with the six white lines lengthwise of the body and the six rows of branched spines; but the spines are yellow instead of black, and the branches scarcely show because they cling closely to the central spines, the

orange body of the caterpillar being fully exposed. But here the caterpillar shows a most peculiar instinct, which results in separating the branches of the spines so that they stand out almost at right angles, making the caterpillar appear as though it were composed of spines only, at

FIG. 129. Full-grown caterpillar. Green, with black-tipped, branched spines (their prick is poisonous). Red and white lateral lines. 2½ inches long. Photographed from life.

least none of the body shows between them. Immediately after the moult each caterpillar puts its head around at one side and the posterior end forward on the same side until the two meet; then keeping them together, it moves them up and over the body, down, and into a corresponding position on the opposite side. Still they are kept

together, and, after a pause, over they go to the first side again. This is repeated again and again until the spines are thoroughly separated by being rubbed together.

After this the caterpillars are very quiet, waiting for the chitinous covering to harden, except that when they are disturbed they all stand up on end and bob in a most ridiculous manner, which is probably threatening in caterpillar world. If the disturbance continues, each caterpillar rolls into a ball completely covered and protected by its armor of spines.


FIG. 130.—Io cocoon and chrysalis. Natural size. Photographed from life.

In each of the moults that follow, the caterpillars use this method of separating the spines. Always after the process the branched spines are so close together that the body cannot be seen between them, but before the next moult, after the caterpillar has spent several days eating and growing, the spines are separated by long distances and the caterpillar is thereby given a very different appearance.

Ios are social until about half grown. When they have attained the adult dress they become independent of one another, no longer feeding and marching together.

The adult caterpillar is very little like the young caterpillar in appearance (Fig. 129). It is two inches or more long, vivid green in color, still in its armor of branched spines, which are green, tipped with black. The characteristic that will serve always to identify the Io is a double stripe along the sides of the nine segments corresponding to the abdomen of the moth ; the lower of the

two is white, the upper is red. This caterpillar should not be handled, as the prick of the spines is slightly poisonous, producing a sensation stronger and more lasting than that given by a nettle leaf.

When the caterpillar is ready for the change to the chrysalis it descends to the ground and makes a thin

FIG. 131.—Opened Io cocoon showing chrysalis and moulted caterpillar skin. Tachina fly chrysalides show the fate of the Io.

irregular cocoon among the leaves. Within this cocoon the chrysalis (Fig. 130) sleeps soundly all winter, and from its shelter the moth awakes when it feels the warm sun shining down on it the following June.

Although the Io caterpillar seems so well protected by its poisonous spines, it cannot and does not escape its parasitic enemies (Fig. 131). Many an Io is sacrificed to the larvae of the Tachina fly. So long as it can eat food enough to maintain its own life and that of its parasites

development goes on; but when it forms the chrysalis and can no longer eat, it is totally destroyed. The Tachina fly larvæ, after they are full-grown, eat their way out of the chrysalis shell. They form their own dark-brown chrysalides, from which will come the adult flies, ready to search for other Io larvæ in which to deposit their eggs.

THE CECROPIA EMPEROR

FIG. 152. — Cecropia cocoon (lowland form; compare with Fig. 144). Made of brown silk and securely fastened to a branch. Natural size. Photograph.

THE CECROPIA MOTH[1]

The largest of the Giant Silkworm group of moths, and one of the most common over the greater part of the United States from the Atlantic coast to the Rocky Mountains, is the Cecropia. The giant brown cocoons (Fig. 132) can be found in the fall and winter, after the leaves have fallen, attached to the branches of trees and shrubs used as food plants by the caterpillars. These food plants are very numerous indeed; Cecropia is known to feed on fifty or more varieties of plants. Probably we shall be most successful in finding them when we look on wild cherry, alder, and willow; but we must expect to find them on very many fruit and shade trees.

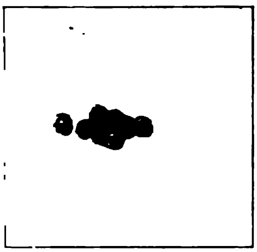


FIG. 133.—Cream-white eggs of Cecropia. Natural size.

The cream-white eggs (Fig. 133) are laid on the undersides of the leaves in small clusters. They hatch (Fig. 134) in ten or twelve days unless they have been appropriated by some parasite, Cecropia in the egg state having many such enemies (Fig. 135). The young

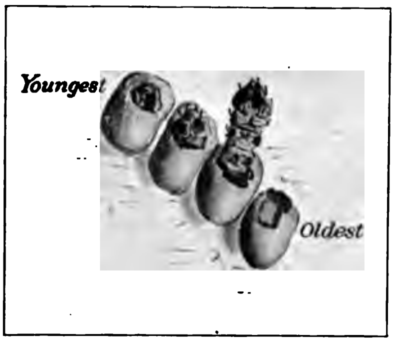


FIG. 134.—Young Cecropias escaping from the eggs. Greatly enlarged.

[1] *Samia cecropia* (Sa′mi-a ce-cro′pi-a) of the Giant Silkworms.

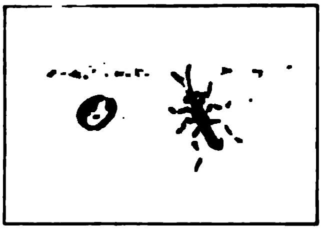


FIG. 135. — Cecropia egg and parasite. Magnified.

caterpillar is black, with small tubercles and stout black spines. Compared with most caterpillars just out of the egg, Cecropias are large, being about as large as Prometheas three days old (Fig. 100).

They eat and grow, moulting their skins, as do all caterpillars. When about three-fourths of an inch long they are bright yellow or orange, with black tubercles (Fig. 136). At the next moult they become green, with light blue backs and with blue and yellow tubercles. Four tubercles near the head are bright orange in color, and all tubercles bear stout spines (Figs. 137 and 138).

FIG. 136. — Moulting Cecropias. Bright orange, with black tubercles; moulted skin black. Photographed from life.

The adult dress of the caterpillar differs very little from this. It is dull green along the sides, and light blue the whole length of the back; there are two rows of blue tubercles along each side, and two rows of yellow ones along the back; there are four large red tubercles on the second and third segments near the head. The caterpillar

FIG. 137. — Cecropias after second moult. At home on wild cherry. Photographed from life.

attains a length of three and one-half or four inches and is as thick as one's thumb. When the caterpillar is ready for the change to chrysalis all the blue color of the body is lost, the whole becoming dull green (Fig. 139).

Perhaps no caterpillar is better adapted for study. Cecropia is very large; it is brilliantly colored, the segmentation is very distinct, the spiracles are conspicuous, the prolegs are especially large and strong and well provided with strong hooks, and the mandibles are large and powerful. When there is a whole brood of Cecropias, from twenty to two hundred or more in captivity, the noise made by these jaws when used in rapidly cutting the leaves is like a continuous shower of fine hail against the window.

It is always interesting to watch the attitude of caterpillars toward one another when there is a whole brood together in captivity. In the case of social caterpillars, such as Prometheas or Ios, they seem to recognize

FIG. 138.—Cecropia in immature dress. Sides green, with blue tubercles; back blue, with yellow tubercles; four large orange tubercles on second and third segments. Photographed from life.

one another's presence and to enjoy close contact with one another; in the case of some solitary caterpillars like the Milkweed, the presence of other Milkweed caterpillars seems most disagreeable, and contact is avoided whenever possible. With Cecropias the relation is different; they seem to have no conception of one another as living beings; they are neither attracted nor offended; they walk over one another; they attach ropes of silk to one

FIG. 139. — Full-grown Cecropia larva looking for place in which to build cocoon. Dull green, blue tubercles along sides, yellow tubercles along back, four large red tubercles near head. Length 3½ inches. Photographed from life.

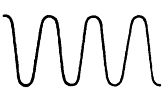
another when building cocoons; they are no more to one another than so many leaves or sticks.

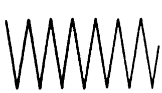
Another point which makes Cecropia well adapted for study is the great size of the cocoon and the fact that it is spun in plain view, not concealed by leaves. In the labor of spinning the cocoon, the caterpillar is indefatigable; it shows great muscular strength and control of its strength; its great flexibility of body is of vast service; and it also uses what seems to be ingenuity.

A corner of a box is chosen, or a branch which has other branches or leaves near it. Long support ropes are placed, and placed advantageously, the true legs being used as hands in managing them. In fastening these supports, the caterpillar reaches out three inches or more, remaining attached by two or three pairs of prolegs only, and never losing its balance. After this great framework is made, shorter ropes are placed from one support to another, filling in the large spaces of the framework with a coarse network. In this and all the later spinning, whenever one thread of silk touches another it remains attached to it because of the glue exuded with it.

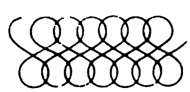
FIG. 140. — Cecropia cocoon cut open to show structure. Firm outer and inner cocoons connected by coarse network. Inner cocoon varnished on the inside and open to exterior at the top. ¾ natural size. Photograph.

After the cocoon is blocked out with this scaffolding of long ropes and the coarse network,





the caterpillar spins a fine network, covering the coarse network on the inside. In this work the silk is put on in connected figure eights, or



in advancing right and left curves, or sometimes in almost parallel lines with sharp turns; it is always put on to fit the space. As a part of the network

is completed, the caterpillar's body is pressed against it and considerable force is used to curve it smoothly out.

The cocoon is a double one, with a coarse network of silk between (Fig. 140). The caterpillar is twenty-four

FIG. 141. Cecropia chrysalis resting in cocoon, posterior end on moulted skin, head just below opening. Natural size. Photographed from life

hours building the outer one, and at least as long building the inner one, in fact it can usually be heard working inside after two days have elapsed. The cocoon is left open at the upper end with a conical valve like that of Promethea (Fig. 109). When first made the cocoon is glistening white, but soon becomes brown.

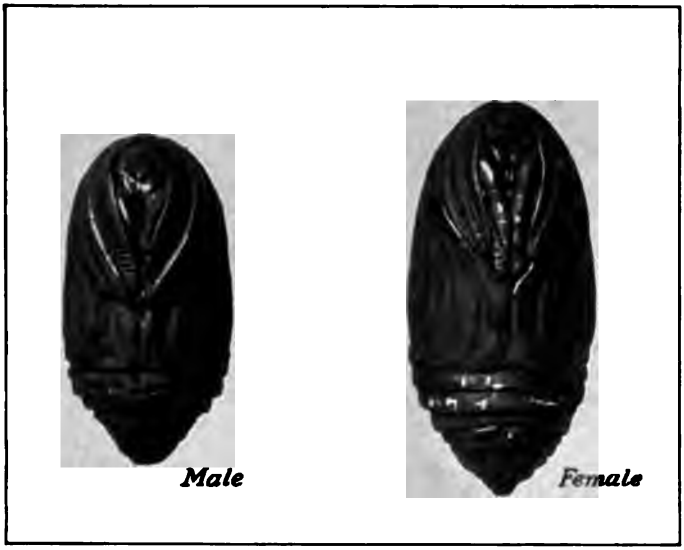


FIG. 142. — Front view of the Cecropia chrysalis to show parts of the undeveloped moth. (Compare with Fig. 114.) Photographed from life.

The large, heavy, brown chrysalis fits the cocoon closely: the head is at the top just below the opening, the posterior end rests on the old moulted caterpillar skin (Fig. 141; compare with Fig. 111). The chrysalis is a very good one in which to identify the various moth parts, the segments, spiracles, wings, antennæ, etc. (Figs. 142 and 143).

FIG. 143. — Side view of Cecropia chrysalis. (Compare with Fig. 114.) Photographed from life.

The Cecropia cocoons vary greatly both in size and shape. We might expect a variation in shape, for that must depend so largely on the situation chosen and the adjacent supports to which the framework may be attached. But why should some Cecropia cocoons be twice as large, even three times as large, as others?

The caterpillars vary greatly, as we should expect, in size and strength. The largest, strongest caterpillars can place the longest support ropes, and can push out to a greater distance with their strong bodies the network of the outer cocoon as it is made; these will have giant cocoons. The smaller, weaker caterpillar cannot reach so far, and as a result the cocoon will be less imposing.

FIG. 144. — Hillside form of Cecropia cocoon. Natural size. (Compare with lowland form, Fig. 132.)

This is true of caterpillars in captivity. In nature low swampy land usually yields large puffy cocoons (Fig. 132), perhaps because such land produces a thrifty fresh growth of shrubs, and the size of the caterpillar depends on the quantity and quality of its food. Dry hillsides usually yield small cocoons (Fig. 144), probably because vegetation is less thrifty there.

FIG. 145. — Cecropia moth with small wet wings, just out of its cocoon. Photographed from life.

Fig. 146. — Cecropia moth (male). Wings dusky brown, with red, white, and clay-colored markings. Body boldly marked with red and white. Broadly feathered antennæ. ⅔ natural size. Photographed from life.

Fig. 147. — Cecropia moth (male). Alert position. ⅔ natural size. Photographed from life.

The moths leave their cocoons in May and June. The Cecropia moth is one of the largest to be found in any country, often having an expanse of six and one-half inches across the wings. It is the largest silk-spinning insect in the United States.

The moth is a very handsome one (Figs. 146 and 147 The general coloring is dusky brown, with markings of red and white. There is seen here the beautiful blending of colors, which is a characteristic of all moth wings, in distinction from the bold contrasts of color seen in the butterfly wings. It would be a most artistic fabric that imitated the pattern and the coloring of the Cecropia wings.

The Cecropia has occasionally stripped the leaves from the shade trees of our cities, but, as a rule, its many parasitic enemies keep the balance in nature. Many observers have reported that woodpeckers tear open the cocoons in winter and feed upon the chrysalides.

THE AMERICAN SILKWORM, OR POLYPHEMUS MOTH

"More servants wait on man
Than he'll take note of. In every path
He treads down that which doth befriend him."

Fig. 148.—Polyphemus in resting position. Male. ¾ natural size. Upper surface of wings. Ochre yellow, with transparent spots at centers of wings. Photographed from life.

THE AMERICAN SILKWORM [1]

WE can gather many cocoons in the fall. The Promethea and Cecropia cocoons are easily found, because they are made on branches and are very conspicuous when the leaves have fallen. The Polyphemus cocoons (Fig. 149) are very nearly or quite as common as these, but are not

FIG. 149. — Polyphemus cocoons. They have no opening for escape of the moth. ¾ natural size.

so easily found. They are made among the leaves on the trees and fall with these leaves, so that our best chance for finding them is to search on the ground under the oak trees, under the elms, and sometimes under butternuts, maples, or lindens.

They are oval, light in color, and are strong and thick, securely closed everywhere. Each is made of a continuous

[1] *Telea polyphemus* (Te'le-a pol-y-phe'mus), or *Attacus polyphemus* (At'ta-cus pol-y-phe'mus).

FIG. 150. Polyphemus chrysalis (male) from which moth has escaped.

thread of silk some eight hundred feet long. There is no great difficulty in unwinding the silk; in fact, several efforts have been made to use the Polyphemus moth in the silk industry, but no great success has attended the efforts so far, because of the cost of labor in this country.

It seems as though there should be success; every element is present: the Polyphemus is hardy, is native, and feeds on our native oaks and elms; the cocoons are large and thick and of an unbroken thread; the silk, though not as fine as that of the Chinese silkworm, is strong and of very brilliant luster. Silk might be as cheap in our country as cotton is now.

As has been said, the cocoon is thick and strong, with no trace of an opening. It is smooth and varnished within. The chrysalis fits it very closely and has at its posterior end the crushed caterpillar skin. The chrysalis shows plainly that it is the undeveloped moth; there is no difficulty in seeing the

FIG. 151. — Polyphemus (male) three minutes after escaping from cocoon. Position taken for further development. (Compare with Figs. 152 and 153.) Natural size. Photographed from life.

abdominal segments, the spiracles, the wings, and the broad feather-like antennæ (Fig. 150).

These chrysalides form the winter state of the moth. In May the moths break the chrysalis skins open only to find themselves prisoners within cocoons. However, each is provided with an acid (bombyc'id) with which it dissolves the gum holding the threads of the cocoon together; pushing these threads apart, the head of the moth makes a round opening at one end of the cocoon. A few vigorous efforts, a tug and a pull, and the legs and antennæ are free, the small wings are loosened from their cases, the large, heavy abdomen is slowly drawn through the small opening, and the moth begins to climb whatever support is near.

FIG. 152. — Polyphemus moth (female) five minutes after leaving cocoon. It hangs wet and heavy from the support. (Compare with Figs. 151 and 153.) Natural size. Photographed from life.

In nature the climb is probably a long one — for we remember that the cocoons fell to the ground with the leaves — and climbing is a slow, difficult matter because the moth is wet and heavy; but at last a place of support is found, and the moth hangs heavily from it (Figs. 151, 152, and 153). It is no longer a prisoner in its snug

Fig. 153. — Polyphemus moth (female) ten minutes after leaving cocoon. (Getting stronger.) Natural size. Photographed from life.

silken house as it has been for nine long months. It is free; it is full of life. The blood courses out into the antennae, out into the wings: the wings expand, stretch out in length and breadth; the colors are revealed, the pattern is unfolded.

In about an hour the moth is in its perfection, though the wings are not yet dry enough or strong enough to be used in flight. The Polyphemus moth measures five or six inches across the wings. Its foundation color is light or dark ochre yellow, usually with a distinct pink tinge.

The wings have at their centers yellow-bordered, window-like spots, which are made more conspicuous on the hind wings by deep borders of black flecked with blue. The other markings of the wings are in shades of brown, gray, and pink, and are as shown in Figs. 148 and 154. The transparent spots of the wings are likely to be smaller in the male than in the female, whereas the feather-like antennæ are very broad in the male and narrow in the female. (Compare Figs. 151 and 153.)

The wings are held extended horizontally while the moth is in resting position. The Polyphemus, like most moths, is a night-flier, and so, although common, is seldom

FIG. 154. — Polyphemus (male) in resting position; under surface. Unopened cocoon and cocoon from which this moth came, at right. $\frac{2}{3}$ natural size. Photographed from life.

or never seen in the woods. Its resemblance to brown leaves helps to hide it from us.

The Polyphemus usually lays its three hundred eggs in small clusters (Fig. 155) on the undersides of the oak and elm leaves, showing the usual instinct of moths and butterflies for laying the eggs on plants which will be food plants for the young caterpillars. However, it is a point of interest that many observers have found that Polyphemus often errs

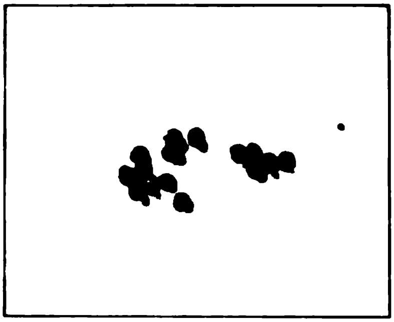


Fig. 155. Polyphemus eggs. Cream color and brown. Natural size.

in the matter, placing the eggs on plants which are not Polyphemus food plants. I have found them even on the rails of country fences far from any plant which is known to serve as food for this moth. It is also known that the very young larvæ of Polyphemus (Fig. 156) and of many other moths will eat plants other than the food plants, plants which they will not touch when older. This lack of specialization in the young caterpillars, together with the fact that moths sometimes place the eggs on plants other than their food plants, helps explain how new food plants and new habits may be adopted, and have been adopted in the past history of these creatures.

Fig. 156. — Young Polyphemus. Magnified. Photographed from life.

The caterpillars come from the eggs in from ten to twelve days. The sharp mandibles cut through the egg-shell at one side. Some caterpillars come out head first in the proper way; others come out tail first, before the opening is large enough to permit the head to pass through (Fig. 157). The shells are usually eaten down to a level with the leaf.

The little caterpillar has a large red head, and a yellow body which soon becomes green. The dress of the

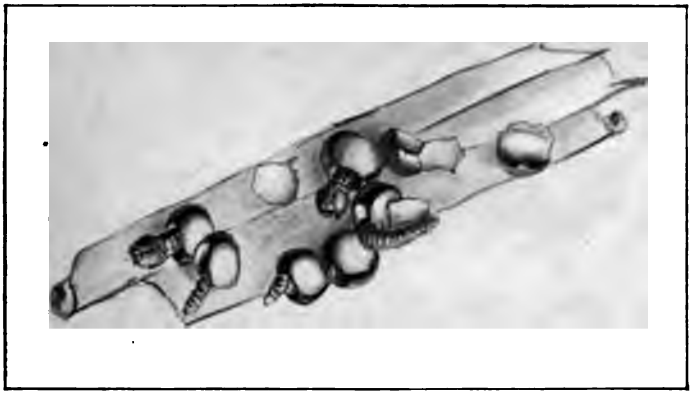


Fig. 157. — Polyphemus caterpillars escaping from eggs. Hole eaten through egg at side, then shell devoured to a level with the leaf. Greatly magnified.

Polyphemus is very nearly the same from first to last; the body is clear translucent green, with longitudinal rows of small tubercles; the head is reddish brown. The segmentation of the caterpillar is very conspicuous (Fig. 156).

In the early stages the tubercles are rose-red at the posterior end, becoming orange toward the head, and yellow on the segment next the head; later all tubercles are yellow or orange, with shining metallic bases. In all stages the tubercles bear a few fine short hairs, and during most of the development the spiracles are bright red. Add to this seven oblique, rather indistinct, yellowish-white

FIG. 158. Full-grown Polyphemus caterpillar in position taken when disturbed. 3 inches long. Translucent leaf-green; longitudinal rows of orange tubercles, with shining metallic bases; seven oblique yellow stripes on first seven abdominal segments; head brown; segmentation very marked. Photographed from life.

lines on the sides of the abdominal segments, and we shall always be able to recognize a Polyphemus caterpillar (Fig. 158).

All caterpillars are rather amusing just after a moult, but Polyphemus is most so: it seems all head and feet, so greatly is the size of these out of proportion with the size of the body. It is said to pass through five moults, and when full-grown to weigh 4140 times the $\frac{1}{20}$ gram it weighs on leaving the egg. Before spinning the cocoon it attains a length of three or three and one-half inches.

When disturbed a Polyphemus caterpillar draws in the brown head so far that the anterior segments of the body

FIG. 159. – Young Polyphemus in pugilistic attitude, exposing itself to view at edge of leaf.

form a great hood for it; at the same time the whole anterior part of the body is thrown to one side and held rigidly there. Polyphemus caterpillars are easily found on young growths of elm and oak, although they are exactly leaf-green and feed on the undersides of the leaves. The feeding is done at the edges of the leaves, and just as soon as the branches are disturbed out comes Polyphemus in a very threatening attitude, apparently to see what is the matter (Fig. 159).

FIG. 160. — Cocoon of Polyphemus containing large cocoon of parasite and remains of Polyphemus caterpillar. This parasite (*Ophion*) is very nearly related to that of Promethea represented in Fig. 121.

This attitude must be really quite terrifying in the caterpillar world, especially as it is accompanied by a loud snapping noise made by the strong jaws. Its protective coloring, its immobility, its terrible attitude, and its snapping jaws are not enough to protect Polyphemus from its foes. The larvæ of more than one variety of ichneumon fly are parasitic upon Polyphemus, finally spinning their cocoons within the cocoons made by the caterpillars [1] (Figs. 160 and 161).

The life history and habits of the beautiful LUNA moth [2] are very much like those of Polyphemus. The caterpillar

[1] Read The Bewitched Cocoons, Gibson's "Sharp Eyes," pp. 67–72; also Comstock's "Manual for the Study of Insects," p. 624.

[2] *Tropæa luna* (Tro-pæ'a lu'na), of the Giant Silkworms.

Fig. 161. Cocoon of Polyphemus cut open to show remains of Polyphemus caterpillar and the many cocoons of its small parasites. Figure at left shows one of these ichneumons (*Cryptus extrematis*) photographed from life.

Fig. 162. Luna cocoon and chrysalis. Natural size.

would be mistaken for that of Polyphemus if we did not observe that the Luna larva has a faint continuous yellow line along each side, and that the seven oblique lines of the Polyphemus are lacking. The larva feeds on hickory, walnut, and birch; and the cocoons

FIG. 163. — Luna moth fresh from its cocoon (tails of hind wings not completely expanded). Wings are delicate green, each bearing an eye-like spot with transparent center. ⅔ natural size. Photographed from life.

(Fig. 162) can be found under these trees, since they are made amongst the leaves and fall as do those of Polyphemus.

The cocoons are very thin, so thin that color can be seen through them and the time of change from the green caterpillar to the brown chrysalis be ascertained. The large light green moth (Fig. 163) is very beautiful indeed and is a great favorite with amateur collectors.

People who have lived long in the country always know it, and in the city it is often found in large numbers about the electric lights.

The Luna is not hardy in any of its stages of development, but with care can be successfully kept in captivity for indoor study.

THE CHINESE SILKWORM

THE CHINESE SILKWORM[1]

THE Chinese Silkworm is exceedingly interesting because it is the silkworm of industry in the old world and the new, the source of all the silk in the world.

FIG. 164. — The Chinese Silkworm. Smooth, cream-white, with a horn at the posterior end, and the anterior segments much wrinkled. 2 inches long. Photographed from life.

The winter is passed in the egg state. In the spring these eggs hatch into minute dark-colored caterpillars, covered with tubercles bearing hairs. They feed upon black or white mulberry or upon Osage orange, and if these are not to be obtained they can be kept alive for a short time on lettuce.

The caterpillars eat greedily and grow rapidly, passing through four moults before reaching maturity. They are very dependent and very quiet; they do not wander away even in search of food. When resting, the head end is elevated and thrown to one side (Fig. 164). The mature caterpillar is two inches or more long, very smooth, and yellowish white in color. It has the thoracic segments enlarged and very much wrinkled, and it bears

[1] *Bombyx mori* (Bom'byx mo'ri), of the family Bombycidæ.

a horn something like the horn of the "Sphinx" caterpillar (Fig. 192) at the hind end of the body on the eighth abdominal segment.

After a development of six weeks,[1] more or less, according to the conditions, the caterpillar stops eating; and, after a day of fasting, spins a cocoon about itself (Fig. 165), moults the skin and becomes the chrysalis (Fig. 167). This chrysalis is unusually small; it lacks much of filling the cocoon. The cocoon may be of golden-yellow silk or it may be white. It is sometimes oval; at other times it is somewhat constricted at the middle. Each cocoon is made of a continuous thread from four hundred to nine hundred feet long, and this thread is fine and of great luster.

FIG. 165.—Spinning Chinese Silkworm, inside of cocoon (at right). Photographed from life.

In about three weeks (the time depending on the conditions) the moth breaks open its chrysalis, secretes the bombycid acid which dissolves the gum holding the silk

[1] To understand the structure of the caterpillar and the process of moulting, refer to the article on Promethea; the process of spinning is described in the article on Cecropia.

threads together, and comes out of the cocoon making a round hole at one end (Fig. 166).

The moth is cream-colored, with several indistinct brown lines on the fore wings. The antennæ are broadly feathered in both male and female (Fig. 168). They are not beautiful moths. They are very small, surprisingly so when one considers the size of caterpillar and cocoon. They have been cultivated in the silk industry for so many hundreds of generations that they are absolutely dependent, not even having the power of flight. In rare cases the male may fly a short distance, always toward the light of course. They never take food, and live only till the work of laying the eggs is accomplished.

FIG. 166. — Cocoons of the Chinese Silkworms from which the moths have escaped. Each contains a shriveled caterpillar skin and an empty chrysalis skin. Photograph.

The eggs are about three hundred in number.[1] They are cream-white, but if fertile become dark in color soon after they are laid.

If the silkworms are raised for commercial purposes, they are allowed to spin in artificially made frames, or

[1] Silkworm eggs or cocoons can be obtained from Mrs. Carrie Williams, San Diego, Cal.

in a natural framework of fine dry branches of shrubs or weeds of some sort (Fig. 218). Six or nine days after the cocoons are made, they are removed from their supports, and the chrysalides within are killed by exposure to steam, or by being put into hot water. Hot water also dissolves the gum holding together the silk threads. The outer ends of the threads of several cocoons are found,

FIG. 167. Cocoon of Chinese Silkworm cut open to show chrysalis and moulted caterpillar skin. Photographed from life.

placed together, and as the cocoons are unwound these cling together to form a thread of raw silk.

Silk manufacture is one of the three great textile industries of the world and is carried on chiefly in China, Japan, France, and Italy. Southern California in the United States has a climate especially well adapted for silkworm raising.

The history of the silk industry is most interesting, especially that chapter which concerns the industry in

the United States. It has not met with great success here; first, because the caterpillar is not a very hardy one, being subject to several contagious diseases; second, because we have no large areas of mulberry trees on which it can feed; and third, and most important, because unwinding the cocoon is so slow a process, and the cost of labor in our country is so great that the business is not a profitable one. The problem of silk production in the United States received the attention of the Agricultural Department at Washington, D.C., for several years, and was finally reported upon unfavorably.

FIG. 168. — The Chinese Silkworm moth on mulberry leaf. Cream-white in color, with broadly feathered antennæ. Photographed from life.

THE TIGER MOTHS

THE WOOLLY BEAR (ISABELLA TIGER)
THE YELLOW BEAR
THE HICKORY TIGER
THE HARLEQUIN MILKWEED

THE TIGER MOTHS[1]

The Tiger moths form a large group, so named because the wings are usually conspicuously striped or spotted. As a rule, the adult of the group has considerable beauty. The wings are folded roof-wise over the back when the moth is resting. The "tongue" is fairly well developed.

The Isabella Tiger moth[2] is one of the most common of the group. Its larva, the Woolly Bear (Fig. 169), is the "evenly clipped" brown and black hairy caterpillar that we see scurrying along in the fall. In the road or on the walks, morning, noon, or night, it always seems in a great hurry to reach some destination.

This caterpillar is one that hibernates, a comparatively rare thing among the common caterpillars; and this hurry in the fall is in search of some protected place for the winter sleep. Finally each rolls itself into a ball under some stone or log or perhaps under a sidewalk, and remains motionless during the winter months.

Early in the spring they come out from their hiding places and break their long fast, eating almost any herbaceous plant that is at hand. Very soon the cocoon is made. It is a thin web of silk that entangles the caterpillar's hairs as they are shed, so that the whole cocoon seems to be made of them.

[1] The Arctiids (Arc′ti-ids). Read Comstock's "Manual for the Study of Insects," pp. 317–324.

[2] *Pyrrharctia isabella* (Pyr-rharc′ti-a is-a-bel′la).

Fig. [illegible]. Woolly Bear, larva of the Isabella Tiger moth covered with equal length brown, with black at the ends. Natural size. Photo[illegible] from life.

After a brief stay in the chrysalis the moth comes out. It is small, tawny yellow in color, with a few dark spots on head and body. The upper surfaces of the legs are red, tipped with black. This moth flies at night and is attracted through the windows to circle about the lights in the house.

The Yellow Bear[1] caterpillar is still more common. It feeds on all sorts of wild herbaceous plants and has made itself a nuisance in vegetable gardens. It is covered with long yellow hairs of uneven length, some of the hairs being fully twice as long as others. It varies greatly in

[1] Spilosoma Virginica (Spil-o-so-ma Vir-gin-i-ca).

color, showing almost any shade between yellow and deep brown.

This caterpillar is interesting in its development. The eggs are in large clusters; they look like small pearls, round and shining. A week after the eggs are laid the caterpillars eat their way out, and after nibbling a little at the shells walk away, leaving the transparent iridescent fragments behind. The young caterpillars are covered with light yellow hairs. They drop with a silk line when disturbed. Crowded side by side, they feed on the underside of the leaf, eating through the epidermis into the pulp.

When they are a week old they begin to eat through the leaf, making small holes between the ribs. When they are two weeks old they still live on the underside, converting the leaf into an open network by eating out the fleshy parts between the small ribs. By this time they have passed through several moults and are many shades darker. The hairs covering the body are very uneven in length, some few being fully one-half as long as the body of the caterpillar.

When three weeks old they pursue the same habit of eating. They drop in a ball without the support thread when disturbed. In moulting, the head and body skins are shed separately, as in all caterpillars. When the skin shrivels back over them and they finally walk out of it, they are queer-looking creatures. All the hairs, long and short, are wet and sleeked down close to the body. The hairs are in tufts in six longitudinal rows. The tufts of the row below the spiracles are sleeked straight backward; those of the two rows on each side of the dorsal line are sleeked upward, meeting and crossing the tufts from the other side. Seen from above, the

caterpillar has a decidedly braided appearance. After a few seconds of rest the caterpillar shows the instinct spoken of in connection with Io. It places the head around at one side, the tail forward on the same side, till the two meet; keeping head and tail together, the caterpillar moves them upward, over its back, and downward to a corresponding position on the opposite side. The motion is reversed, then repeated several times; and as a result the hairs are all separated, so that they stand out one from another. The caterpillars now look as though they might be young Woolly Bears; the hairs at the anterior and posterior ends are black, while those in the middle are orange-brown.

FIG. 170. — Opened cocoon, moulted caterpillar skin, and brown chrysalis of the Yellow Bear. Natural size. Photographed from life.

When full-grown they are one and one-half inches long, having passed through many moults. They are evenly colored from one end to the other. They now eat the small ribs of the leaf also.

FIG. 171. — Moth of the Yellow Bear caterpillar. White, with a few black spots on hind wings and underside of wings, and with orange and black on abdomen. Natural size. Photographed from life.

They make irregular cocoons composed mainly of their own

hairs, and pass the winter in the chrysalis state (Fig. 170).

The moth is pure white, with a few small black spots on the wings, and with orange and black on the abdomen (Fig. 171).

The HICKORY TIGER moth[1] is another extremely common form through the Atlantic States and westward.

FIG. 172. — Caterpillars of the Hickory Tiger moth. Hairy; black and white. Length 1½ inches. Photographed from life.

The caterpillars are likely to be more abundant than any others in August and September through half-cleared woodland tracts. This caterpillar is easily recognized

[1] *Halisidota caryæ* (Ha-lis-i-do'ta ca'ry-æ).

when once seen (Fig. 172). It is one and one-half inches long, and densely clothed with tufts of white and black hairs. The black tufts are arranged to form a ridge along the back, there is a long pair of tufts near the head on the first abdominal segment, and another pair near the posterior end on the seventh abdominal segment. The rest of the caterpillar is white; long white hairs project over the head and over the posterior end, and there is a pair of long white tufts on the eighth abdominal segment.

FIG. 173. — Gray cocoon of the Hickory Tiger moth. Made of the barbed black and white hairs of the caterpillar. The hairs extend everywhere at right angles to the cocoon. Natural size.

The caterpillars feed on hickory, butternut, and other forest trees, but also sometimes do damage to apple, quince, etc.

The cocoons (Fig. 173) are oval and gray and are made under stones, fence boards, and in other protected places. They are composed almost wholly of the caterpillar's own hairs. A thin framework of a cocoon is spun around the caterpillar, then the stiff black and white hairs, naturally loosened from their attachment to the skin at this time, are thrust through the silk network, so that they stand straight out in all directions at right angles to the threads of the network. The hairs are finely barbed, so that if one touches the cocoon, hundreds of them remain sticking to the finger.

The moth appears in May and June. It is ochre yellow or brown in color, the fore wings conspicuously spotted with white. It flies at night and is one of the many moths attracted to lights.

The HARLEQUIN MILKWEED[1] caterpillar is another extremely abundant member of this group, feeding (as its name indicates) on the milkweeds which are so common all over our country. It is covered with tufts of orange, black, and white hairs, the tufts near the ends being much longer than the others.

Is this a case of mimicry of the Monarch butterfly caterpillar? They feed together on milkweed, they are colored somewhat alike. Monarch caterpillars are protected by nauseous qualities, therefore this may be a case of protective coloring.

FIG. 174. — Harlequin Milkweed larva. Hairy; black, white, and orange. × 1½. Photographed from life.

The Harlequin caterpillars (Fig. 174) are social. The many eggs are laid on a leaf near the top of the plant. The colony of young caterpillars devours this leaf, leaving the midribs and a few stronger veins of the leaves, then descends to the one below, and so in order downward. These caterpillars never proceed deliberately; like other members of the group of Tiger moths, they always hurry, and they really succeed in covering considerable ground in a very short space of time. They are very quick to put head to tail and drop in a ball to the ground if they are disturbed.

[1] *Cycnia egle* (Cyc′ni-a eg′le).

The cocoon is felt-like, composed largely of hairs from the caterpillar's body, and is tucked away in some protected, out-of-the-way corner.

The moth comes from its winter chrysalis in June; it is a plain little blue-gray creature with unadorned wings, but with a yellow abdomen spotted with black.

THE AMERICAN TENT CATERPILLARS

FIG. 175. Nest of the Cherry-tree Ugly-nest caterpillars. Many small chrysalides are clinging to the outside; one moth is in clear view. Reduced. Photographed from life.

THE TENT CATERPILLARS[1]

Every farmer and every village man knows the Tent caterpillars, probably much to his sorrow; and every country boy and girl knows them, and probably knows also that they are ostracized members of the caterpillar world, at least on well-kept farms.[2]

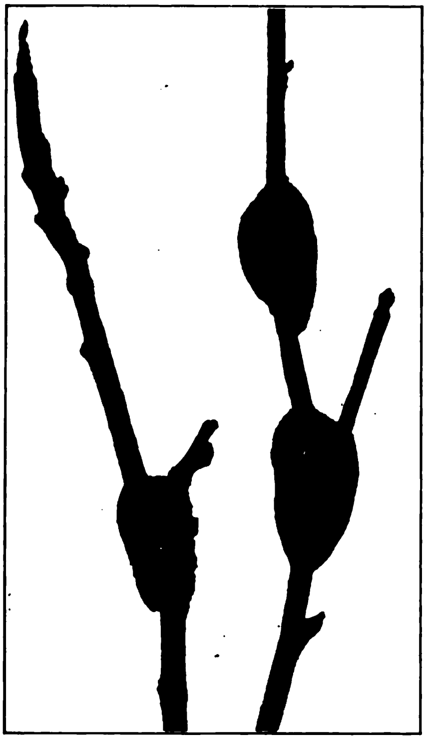


Fig 176. — Brown masses of eggs on wild-cherry branches. American Tent caterpillar. The caterpillars have eaten their way out of the mass at the left. Photograph.

In July each moth lays its hundreds of eggs in a varnished brown mass (Fig. 176) encircling the stems of the apple and wild-cherry trees. These eggs are not hatched until the following spring. They are protected during the months from July to April, both from being eaten by birds and from rapid change of temperature, by their thick, gum-like covering.

[1] *Clisiocampa Americana* (Clis-i-o-cam'pa A-mer-i-ca'na).

[2] *Bulletin 38*, New Hampshire College Agricultural Experiment Station, Durham, N.H.

In April they hatch, and the little caterpillars at once begin feeding on the tender leaves and buds. They very soon begin spinning a network of fine white silk in a fork of the tree, a tent to serve for their protection from birds and during storms. This tent, small at first, has new walls of silk added on the outside from day to day

FIG. 177. – The silken nest of the American Tent caterpillar. Greatly reduced

and week to week, so that it may always accommodate the colony of caterpillars, notwithstanding their daily increase in size (Fig. 177).

The habits of these caterpillars are certainly interesting. They rest in the tent all day, lying side by side as close together as possible. Towards dusk they come forth and march in Indian file to their feeding grounds, the leaves of the near branches. They spin pathways of silk as they march, perhaps to give them more steady footing.

possibly to guide them back to their tent after the meal is over. They are voracious feeders, stripping the branches, or at most leaving only the midribs and perhaps one or two of the larger veins of the leaves. If there is more than one colony on a tree, the leaves may be eaten from the whole tree, so that the caterpillars must travel as do the army worms in search of food.

The mature caterpillar (Fig. 178) is nearly two inches long. The body is somewhat hairy and has a distinct

Fig. 178. — Tent caterpillars and lower part of tent, on wild cherry. Caterpillars 2 inches long; somewhat hairy, with white dorsal stripe; sides spotted and striped with blue and yellow. Reduced. Photographed from life.

white stripe along the middle of the back. The sides are spotted and striped with blue and yellow.

When they are mature they leave the nest and wander until they find some protected place, some stone or fence board under which to spin the cocoon. Some caterpillars of a colony usually spin their cocoons within the nest. The cocoons are oval and yellow, with large quantities of

a peculiar dry, yellow powder among the silk threads. We know that the caterpillars are social, yet we are surprised to find sometimes that two go to sleep in the same cocoon and form two brown chrysalides, lying side by side, with no partition of silk between. Who will find out whether both caterpillars help in the spinning, or whether one caterpillar is taken prisoner in the cocoon of the other, or whether it crawls into the half-finished cocoon of its brother to escape the work of spinning?

FIG. 179. Cocoons of the American Tent caterpillars, showing round holes at head ends through which moths escaped. Natural size. Photograph.

The moths remain in this stage between two and three weeks, until the last of June or the first of July, then come forth, each making a round hole in the head end of its cocoon (Fig. 179). They are small, yellowish brown in color, with the wings folded roof-wise over the body (Fig. 180). Each fore wing is crossed by two light yellow lines (Fig. 181). The antennæ are feather-like in both sexes. The male is considerably smaller than the female.

The Tent caterpillars have many natural enemies. The cuckoos are noted ones, although many other birds are known to feed largely on them in June. They are greatly subject to insect parasites and to various bacterial diseases.

Farmers usually destroy them by burning the tents while the caterpillars are small.

The TENT CATERPILLAR OF THE FOREST[1] is common in forests and sometimes does much damage there. The larva can be distinguished from the American Tent cater-

FIG. 180. — Moths of American Tent caterpillars. Wings folded roof-wise over the body; antennæ feathered; wings and body brown, fore wings crossed by yellow lines. Lower moth at left is male, others are females. Natural size. Photographed from life.

pillar by the fact that it has a row of spots along the back instead of a continuous line. The moth is very similar, but the wings are crossed by dark lines instead of light. The brown egg masses end squarely instead of being rounded like those of the American Tent caterpillar.

[1] *Clisiocampa disstria* (Clis-i-o-cam'pa dis'stri-a).

This American Tent caterpillar must not be confused with the CHERRY-TREE UGLY-NEST caterpillar.[1] In the case of the latter all the leaves and twigs of a branch are fastened together with a large amount of silk to form a nest, and the small yellow caterpillars feed on the leaves enclosed in the nest. Within the nest the caterpillars change to chrysalides, which, when ready for the last transformation, work their way to the exterior so that the moths can escape (Fig. 175).

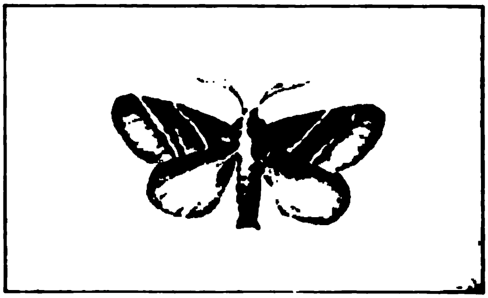


FIG. 181. – The American Tent caterpillar moth with wings spread.

They are not nearly related to the American and Forest Tent caterpillars and are seldom so common as these.

The caterpillars of the SCALLOP-SHELL MOTH[2] also build nests on the wild cherry. These caterpillars are Geometrids, or measuring worms, *i.e.*, they lack the prolegs in the middle of the body, and so must walk with a looping motion, measuring the ground by inches. They bind together with a few silk threads the leaves at the end of a stem, adding new leaves below as more food is needed. Where the Scallop-shell is common these long brown nests

[1] *Cacoecia cerasivorana* (Ca-coe'ci-a cer-a-si-vo-ra'na). Comstock's "Manual for the Study of Insects," pp. 244, 245.

[2] *Calocalpe undulata* (Cal-o-cal'pe un-du-la'ta); read Comstock's "Manual for the Study of Insects," p. 284.

at the ends of wild-cherry branches are very conspicuous. The eggs are red. They are laid in large clusters on leaves near the ends of twigs. The small moth is well named. In resting position, with the wings spread, it imitates a scallop shell, not only in shape, color, and pattern, but also in delicacy.

THE WHITE-MARKED TUSSOCK

THE WHITE-MARKED TUSSOCK[1]

A CATERPILLAR that feeds freely on many kinds of trees and shrubs is the White-marked Tussock. This larva wears a rather distinguished uniform of red, yellow and black, and is always described as one of the most beautiful of our caterpillars (Fig. 182). The head and two glands on the ninth and tenth segments are bright vermilion, and there is a yellow-bordered, velvety black band along the back. Most conspicuous of all is a row of four dense, brush-like tufts of white or cream-colored hairs on the four segments back of those bearing

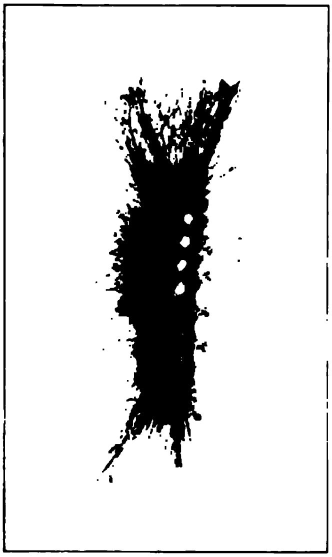
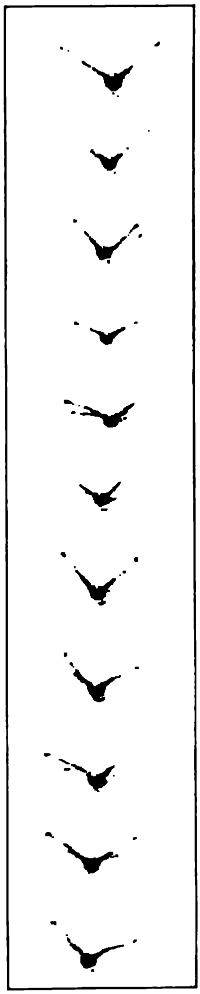


FIG. 182. — The White-marked Tussock larva. Head and two glands on ninth and tenth segments red; long pencils of hairs and dorsal band black; four tufts on back white. Natural size. Photographed from life.



[1] *Notolophus leucostigma* (No-tol′o-phus leu-co-stig′ma).

the true legs (fourth to seventh segments), and two long pencils of black plume-tipped hairs on the first segment and a similar one on the eleventh.

In defensive attitude the caterpillar bends its head down against the support and arches the segments bearing the white tufts high in air. In moulting, the two pencils of long hairs remain attached to the head skin, so that a

FIG. 183. — Eggs of the White-marked Tussock moth, laid in a white frothy mass on the cocoon of the female moth. (The eggs are the winter state of the insect.) Natural size. Photograph.

curious effect is produced, when a number of Tussock caterpillars in captivity are moulting, by the apparently cut-off heads with long black whiskers which lie about.

The caterpillars sometimes become so abundant on apple trees that they do much damage; and more than once they have become a pest on the elms of the cities of the eastern United States.[1] However, they are never

[1] *Bulletin* ..., New Hampshire College Agricultural Station, Durham, N. H.

likely to become such pests as the cankerworm, the army worm, and others. In the first place, they can spread only very slowly indeed, simply through wanderings of the caterpillars, because the female moth is a helpless creature without wings, and so must lay the eggs near the spot in which the caterpillar made its cocoon; in fact, the eggs are usually laid in a white frothy mass on the cocoon itself (Fig. 183). Then, too, the eggs are the winter state of this moth, and we can easily remove them from the trunks and branches of the trees or from the neighboring fences during the winter, especially as they are conspicuous, made prominent not only by the light cocoon back of them, but also by the foamy white mass in which they are laid. The caterpillars are also subject to the attacks of parasites of various kinds (Fig. 184).

FIG. 184. — Dead White-marked Tussock caterpillar and cocoon of parasite.

The cocoon, as has been said, is made on near-by fences or houses and on the trunk and twigs of the trees used as food plants. When the caterpillar is ready for the chrysalis stage the usual signs foretell the change. The fading of the colors is most marked, the red entirely disappears from head and glands, the yellow is gone from the longitudinal bands, the Tussock is a mere ghost of itself.

In making the cocoon the caterpillar has a novel method of spinning the two end walls first. This cocoon is usually a double one, the outer of white silk with the long black hairs entangled in it, the inner with less silk,

but thick with the white and yellow hairs from the caterpillar's body.

Fig. 185. Chrysalides of the White-marked Tussock

Some caterpillars stop eating and spin the cocoons when they are an inch or less long; these are the males. Their chrysalides are small and light-colored (Fig. 185). The caterpillars which are to become the wingless females remain in the caterpillar condition considerably longer and form large dark-colored chrysalides. The chrysalides of both are covered with short soft hairs, especially in the abdominal region.

Fig. 186. White-marked Tussock moth, male. Ashy gray with markings of black and white. Antennae feathered. Note the legs stretched forward when it is in resting position

The male moth (Fig. 186) has well-developed wings folded roof-wise over the body. It is ashy gray in color, rather prettily marked with black and white. It is interesting to find one resting on an old fence or house and see how perfectly its color blends with the gray of the weather-beaten boards. Of course it is also perfectly protected by its color when on the gray tree trunk. When

in resting position the anterior legs are held stretched out in front, and the feathered antennæ are curved backward on a level with the wings.

There is but one brood of the White-marked Tussock each year. It is the most widely distributed of the Tussock moths, but the best known of the family is probably the Gypsy moth, the European species that was introduced into Massachusetts and has caused so much trouble there.

TWO APPLE-TREE DWELLERS

RED-HUMPED APPLE-WORM

YELLOW-NECKED APPLE-TREE WORM

TWO APPLE-TREE DWELLERS

THE "Prominents"[1] is a name given to a rather large family of moths, because of a backward projecting prominence on their fore wings. As Professor Comstock says, the name is more appropriate when applied to the larvæ of these moths, because the majority of them are curiously humped or else take unusual positions so as to elevate various parts of the body.

One of the most common of these is the RED-HUMPED APPLE-WORM.[2] It is social in its habits and is sometimes in such numbers that it weighs down the branches of the apple and wild-cherry trees, and if not disturbed, will completely strip the infested branches.

You may find them resting close together on the undersides of leaves just before their last moult. They are rather conspicuous then, with very dark brown bodies and black heads. After the moult, when in their adult dress, they are quite different in coloring. The head and a large hump on the fourth segment are red, the body is striped lengthwise with fine lines of yellow, black and white, and there are short black spines along the back. The posterior end (three segments) is lifted when the caterpillar is disturbed in any way, or sometimes when it is in resting position. If ugly looks drive away enemies in caterpillar world, this caterpillar must

[1] *Notodontidæ* (No-to-don′ti-dæ).

[2] *Œdemasia concinna* (Ed-e-ma′si-a con-cin′na).

be quite unmolested, for it certainly is a most disagreeable-looking object.

In July the full-grown caterpillars spin very thin cocoons among the leaves on the ground and, curiously enough, remain as caterpillars within the cocoons for two weeks, then moult the skins and reveal shining brown chrysalides, which pass through the final transformation three or four days afterward.

The moth presents one of the best instances of protective resemblance that I have ever seen. It is brown and gray, the fore wings are folded over the hind wings, and then both pairs are rolled tightly about the body so that the moth looks like a slender brown and gray apple twig; the rounded end of the abdomen protrudes from the rolled-up wings and increases the resemblance to a twig by its own close likeness to a bud at the end of the twig (Fig. 187).

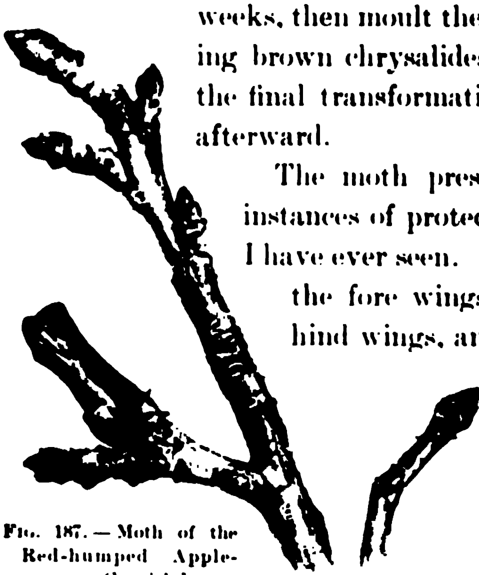


FIG. 187. — Moth of the Red-humped Apple-worm. Grayish brown wings rolled about body. Protected by resemblance to apple twig.

There is a second brood of caterpillars which form their thin cocoons on the ground in the fall and sleep in them all winter (Fig. 188), changing to chrysalides only a short time before their emergence as moths in the spring.

Another very common caterpillar is the YELLOW-NECKED APPLE-TREE WORM.[1] It also lives in colonies and, if

[1] *Datana ministra* (Da-ta'na mi-nis'tra).

unmolested, will do considerable damage to various fruit and forest trees, especially to apple and oak. The caterpillars are black, conspicuously striped lengthwise with yellow or white, and, in accordance with their name, have a yellow or orange spot on the first segment next the head. They have the most curious habit of elevating the anterior and the posterior parts of the body until they nearly or quite meet above the back, remaining attached to the support by the middle prolegs only (Figs. 189 and 190). Also when disturbed they send forth from the mouth quantities

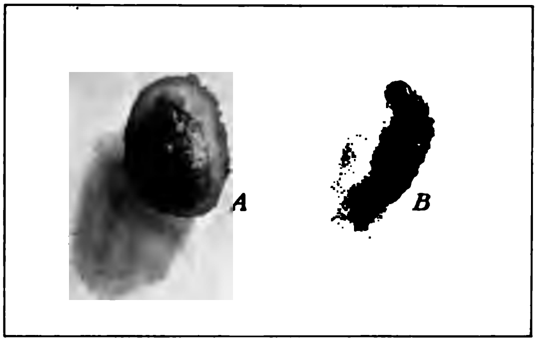


FIG. 188. — Red-humped Apple-worm. *A*, thin cocoon, made in August. *B*, live caterpillar removed from cocoon the following May, a few days before its change to chrysalis. Photographed from life.

FIG. 189. — Yellow-necked Apple-tree caterpillars in adult dress and typical position. Black, striped with yellow or white; a yellow spot on first segment back of head. Natural size. Drawn from photograph.

of a green fluid. Certainly these also are ugly-appearing enough to be avoided by enemies.

When the change to chrysalis approaches, the caterpillars descend a few inches into the ground and there moult the skin. The chrysalis is the winter state; in fact, the chrysalis state lasts fully nine months. The moths appear in June and July. The species is single-brooded.

FIG. 190. — Moulting Datana caterpillars. Left one in ordinary resting position, but showing the large new head back of the old head skin; right one somewhat straightened, ready for struggle out of skin, which is just beginning to split over new head; middle one partially escaped from old skin and working to free old head skin. Photographed from life.

The moths are brown, with buff hind wings; they have a patch of red brown on the back of the thorax, and lines of dark brown across the fore-wings. In the case of these moths — as in almost all of the moths — the larvæ are better known than the adults, because the latter are night-flying and in the daytime are wonderfully protected in their hiding places by their various combinations of brown and gray coloring. On the other hand, the caterpillars are very often gregarious in habit and become conspicuous because of their numbers. Just the reverse is apt to be true in regard to our common butterflies.

THE SPHINX MOTHS

THE FIVE-SPOTTED OR TOMATO SPHINX
THE TWIN-SPOTTED SPHINX
THE PANDORUS SPHINX
THE "HOG-CATERPILLAR OF THE VINE"
THE WHITE-LINED OR PURSLANE SPHINX

FIG. 191. — White-lined Sphinx. Fore wings and body olive-brown. Conspicuous band of buff across each fore wing. Hind wings black, with central band of rose color. Slightly enlarged. Photographed from life. (Compare with Fig. 209.)

THE SPHINX MOTHS

THE Sphinx moths form a group of the moths and butterflies which is very distinctly marked in each of the three stages of development: caterpillar, chrysalis, and adult. The caterpillars are usually green, with oblique lines along the sides; the body is cylindrical and naked, usually bearing a curious horn on the top of the eleventh segment. This horn is never provided with a sting, and its use is quite a riddle. Its value would be more apparent if it were at the anterior end; perhaps in caterpillar world it is considered ornamental. The stories which are frequently abroad to the effect that people have been poisoned by these caterpillars must be quite without foundation; Sphinx caterpillars are perfectly harmless.

Sometimes, when resting or when in any way molested, these caterpillars take a threatening attitude in which Linnæus[1] thought they bore a resemblance to the Egyptian Sphinx, hence the name of the group. The anterior part of the body back to the second or third pair of prolegs is lifted into the air and the head is curved forward. This position is maintained rigidly for hours.

The chrysalides usually have a shining brown exterior. They are long and taper gradually toward the ends. The long tongue case is conspicuous; it is usually in the accustomed position for this organ in chrysalides of all sorts, but sometimes it is separated from the body of

[1] Linnæus (Lin-næ'us), a noted naturalist of the eighteenth century, the "Father of Natural History."

the chrysalis and forms a curved handle, often compared to the handle of a jug. The chrysalis is usually formed underground.

The adults of this family are easily recognized. The body is large and spindle-shaped. The antenna is more or less thickened, — sometimes in the middle, sometimes toward the tip, — and the end is usually recurved to form a hook. The wings are long and narrow and very strong, and give the name Hawk moths to the group.

Many of these moths are very beautiful. Comstock says of them: "Of all the beautifully arrayed Lepidoptera some of the Hawk moths are the most truly elegant. There is a high-bred, tailor-made air about their clear-cut wings, their closely fitted scales, and their quiet but exquisite colors. The harmony of the combined hues of olive and tan, ochre and brown, black and yellow, and grays of every conceivable shade, with touches here and there of rose color, is a perpetual joy to the artistic eye. They seldom have vivid colors, except touches of yellow or pink on the abdomen or hind wings, as if their fastidious taste allowed petticoats only of brilliant colors always to be worn beneath quiet-toned over-dresses."

There are about one hundred species of Sphinx moths in the United States. Of these the following five are among the most common.

The TOMATO SPHINX,[1] or FIVE-SPOTTED SPHINX, is probably the best known of all. The caterpillars feed on tomato, also on potato and tobacco wherever they

[1] *Macrosila quinquemaculata* (Ma-cro′si-la quin-que-mac-u-la′ta), ***Phlegethontius celeus*** (Phleg-e-thon′ti-us ce′le-us), or ***Protoparce celeus*** **(Pro-to-par′ce ce′le-us).**

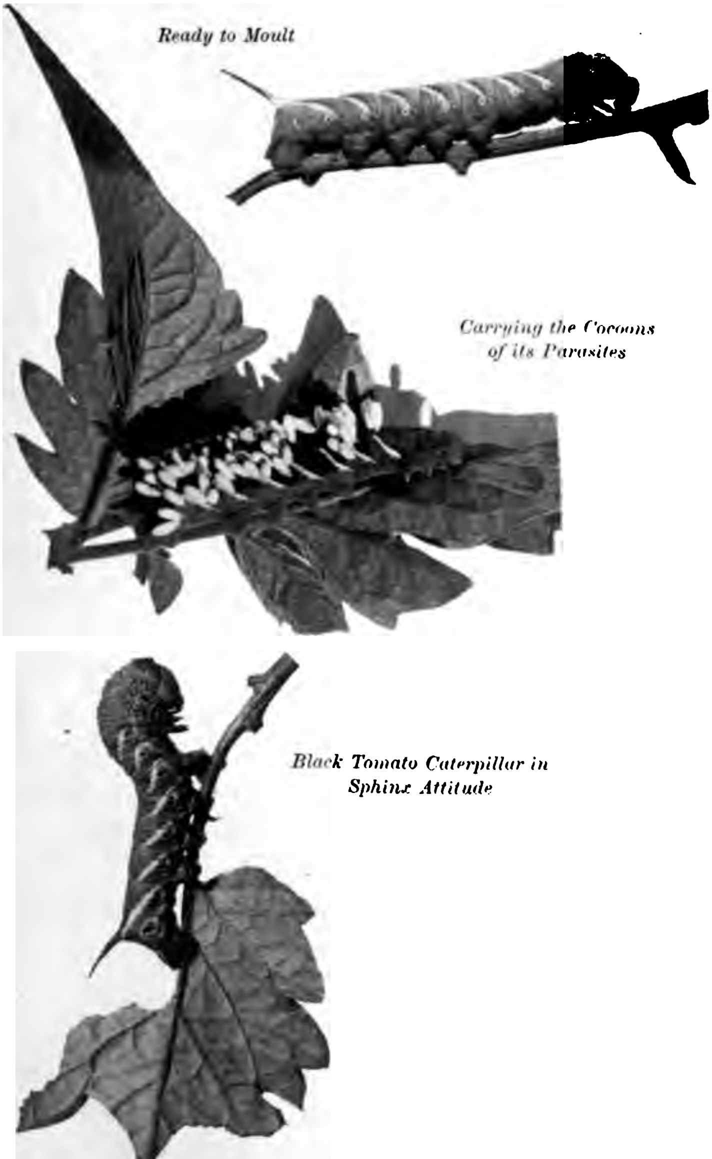


Fig. 192. — Tomato Sphinx larvæ two-thirds grown. Green, with caudal horn, and with seven oblique white lines on each side. Photographed from life.

are grown in the United States. They eat even the young fruits of the tomato. The caterpillar is the typical Sphinx caterpillar and is admirably adapted for study because of the clearness with which all points of structure are shown (Fig. 192).

It is usually leaf-green, but sometimes dark brown or black ones are found (Fig. 192) which look so different that we might think them of another species if we did not keep them and find that they become the same sort of moth produced by the green larvae. The white lines on the first seven abdominal segments pass obliquely backwards from points below the spiracles to the mid-line of the back; they are bordered above by short dashes of black; the last two lines meet at the posterior end of the caterpillar at a point from which grows a curved red horn. The nine pairs of spiracles are very prominent; they are black, bordered above and below by white. It is one of the best caterpillars in which to see the working of the jaws and the use of the true legs in managing the food. The leaves are eaten systematically, so that no part is wasted. We are all familiar with the appearance of the skeleton tomato and potato plants left standing to tell — when it is too late from the farmer's standpoint — the story of the caterpillar's growth.

These are large caterpillars, yet it is wonderful how well they are protected by their green color and their white lines. It is not easy to locate them on their food plants until they are very large, and even then we may look directly at them and not see them, so like are they to the mass of stems and foliage about them.

The young caterpillars dress quite like the full-grown ones, but they are surprisingly long and slender, and the

horn is fully one-third the length of the whole caterpillar. The moults take place just as in all the caterpillars described: a carpet of silk is spun, the head is drawn backwards out of the head skin, the skin splits over it, and head and body skins are shed separately. The horn is drawn out of its old skin and is left curved backwards over the posterior end of the caterpillar for some time, and then is gradually straightened.

FIG. 193. — Tomato caterpillar burrowing into ground head foremost. $\frac{2}{3}$ natural size. Photographed from life.

When angry these caterpillars take the sphinx attitude, swinging the body from side to side, at the same time producing a snapping noise with the powerful jaws. It is amusing to watch several when they are in captivity together. When one of them touches another, if it does not get out of the way quickly it is likely to be tumbled from its support by the powerful strokes given it by the angered caterpillar.

FIG. 194. — Tomato Sphinx chrysalis. Proboscis in external case. Natural size. Photographed from life.

When the caterpillar approaches the change to chrysalis, it becomes darker green and finally dull purplish brown. It ploughs down

into soft earth head foremost, as though it had been used to living underground all its life (Fig. 193). If it meets any large obstruction a short distance below the surface, it is apt to come up and try another spot. At last it finds a suitable place several inches below the surface and there hollows out a little room for itself by rolling over and over, strongly arching the central part of the body, and using head and tail as pivots.

After a week or a little less, during which the caterpillar contracts very much, its skin is shed, head and body skin together, and the chrysalis is displayed (Fig. 194). At first it is green in color and very soft; twenty-four hours later it is somewhat hardened and has become a rich brown. It rests in its cell below ground until spring. Why did not the caterpillar spin a cocoon? It does not need one; it is protected from injury from external objects, it is away from strong light, it is cool and moist, and safe from sudden changes of temperature. The earth is a better protection than a cocoon would be.

However, it may be disturbed, since its food plants are cultivated plants and the ground must be ploughed; and so they are often turned out of their cozy burrows and left upon the surface of the earth, where they become dry or are eaten by birds or meet destruction in some other way.

If they are not molested, these chrysalides work their way to the surface of the earth in late spring or early summer, and the moths escape. They are handsome creatures, measuring four or five inches, of powerful wing, and with a proboscis of extraordinary length (three or four inches). The fore wings reveal many blending shades of gray with touches of black; the hind wings are

crossed by four prominent bands of black; the body is gray, with five square yellow patches along each side (Fig. 195).

Because of the extraordinary length of its proboscis, this moth is able to get the nectar from some of our deepest flowers. As it flies rapidly and directly to the honeysuckles, and poises on vibrating, whirring wings

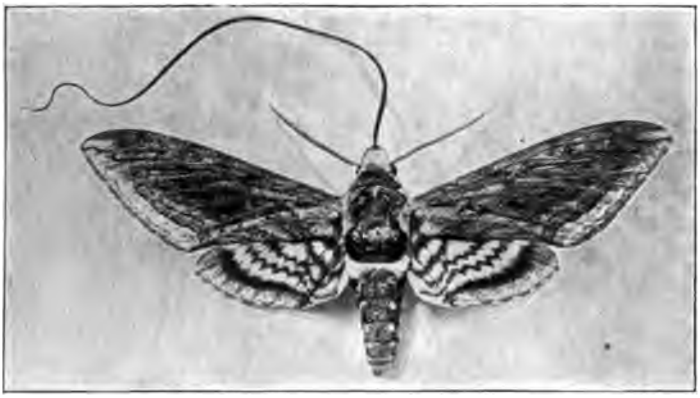


FIG. 195.—Tomato Sphinx moth. Wing expanse 4 to 5 inches; fore wings marked with many shades of gray; hind wings crossed by prominent bands of black; body gray, with five square yellow spots on each side; tongue 3 to 4 inches long. Photographed from mounted specimen.

before them to thrust its long proboscis to the depths of their tubes, we are filled with wonder at its strength and freedom, and we see the aptness of its name of Humming-bird moth; in fact, it is so bird-like that we are likely to be deceived until we look closely.

There are many flowers which are thoroughly dependent on the various Sphinx moths for pollen to help make their seeds. These flowers have long tubes or spurs with enticing nectar at the bases, and pollen bags so arranged that they must come in contact with the moth's head or eyes when the "tongue" is thrust to the depths of the

tube or spur. The relation between the Sphinx moths and flowers is a most interesting one; the former are really invaluable, making possible many kinds of our most beautiful and serviceable flowering plants.[1]

The TWIN-SPOTTED SPHINX[2] is a most beautiful little moth (Fig. 196) and is rather common. The wings measure about two and a half inches from tip to tip. The upper wings are grayish brown, crossed by many blended bands of lighter and darker brown; one band midway the length of the wing is deep chocolate. There is also a chocolate-brown semicircular spot at the tip of each fore wing, and a patch of similar color on the back of the thorax. The lower wings are carmine, shading to light rose near the body; each is bordered with tan and has a velvety black patch containing two blue spots, the origin of the name Twin-spotted. The under surface of the wings is banded with

FIG. 196. — The Twin-spotted Sphinx (female). Expanse of wing 2½ inches. Fore wings blended shades of brown and gray; hind wings carmine, with two spots of blue set in velvety black. Drawn from life. (Position taken when wings are vibrating just before flight.)

[1] A Few Native Orchids and their Insect Sponsors, Gibson's "My Studio Neighbors," pp. 171-224. Harper & Brothers.

[2] *Smerinthus geminatus* (Sme-rin'thus gem-i-na'tus).

wavy lines of white and orange-brown, and there is much rose color near the body, especially on the fore wings. This moth flies only at night and lacks the direct powerful flight of most of the Sphinxes; it has also a poorly developed proboscis.

The larva (Fig. 197) is green, with a rough granular skin, and with the head distinctly triangular in shape. It burrows into the ground in the fall, and becomes a brown chrysalis (Fig. 198) without the external "tongue" case so conspicuous in the Tomato Sphinx.

FIG. 197. — Twin-spotted Sphinx larva in typical sphinx attitude. Head triangular; skin rough and granular; body green, with seven oblique yellowish lines on each side. Enlarged. Photographed from life.

The caterpillars feed on elm, willow, oak, ash, apple, etc., and the chrysalides may be found in the soil at the bases of these trees.

This caterpillar, as is the case with most Sphinx caterpillars, is greatly subject to parasites. It is a very

common thing to see caterpillars completely covered with oval white objects standing on end which look like eggs at first sight (Figs. 199 and 192). They are the silken cocoons of minute microgaster flies[1] which have developed from eggs laid within the body of the Sphinx and have come through its skin and spun their cocoons fastened to its body. Of course the life of the Sphinx is always sacrificed, and hundreds of the progeny of the original parasite that laid the eggs go forth to repeat the story and seal the fates of as many other Sphinx caterpillars.

Fig. 198. — Chrysalis of the Twin-spotted Sphinx. Slightly enlarged. Photographed from life

The Pandorus Sphinx[2] in its larval stage feeds on grape and Virginia creeper. We may find the young

Fig. 199. — Geminatus larva bearing many silken cocoons of its parasite. Many cocoons have been removed to show holes in skin through which the parasitic larvæ passed. Enlarged. Photographed from life

[1] Read Comstock's "Manual for the Study of Insects," p. 625

[2] *Philampelus pandorus* (Phi-lam'pe-lus pan-do'rus).

caterpillar (Fig. 200), one inch or more long, resting on the stems of the leaves. It is usually green, but sometimes distinctly pink in color. It has a red caudal horn, long and slender, and curled forward like a pig's tail. It has four oval cream-colored spots on the sides of the body, which produce eye-like effects because of the dark spiracles at their centers. Most conspicuous of all is the abrupt cut-off appearance at the head end, brought about by a withdrawal of the head and first two segments into the swollen two segments which follow. This is one of the so-called "Hog-caterpillars," and we at once see the appropriateness of the name.

FIG. 200. — Young Pandorus Sphinx. Green; horn red; oval spots cream-colored.

The process of shedding the skin is precisely the same here as elsewhere among moths and butterflies. The skin splits over the head, which has been drawn backward out of the head skin, the body skin shrivels backward to the second pair of prolegs and there halts until the caterpillar removes the head skin from over its mouth-parts, making effective use of its true legs. Then, through vigorous efforts of the caterpillar, the skin is removed from the hind end of the body. It is interesting to watch the red horn slowly withdrawn from its old tight-fitting skin, leaving that skin white and transparent. After the moult this horn stretches straight backward from the body, but the caterpillar at once lifts it, brings

it into position above the back, and curls it (Fig. 201). The young caterpillar seems to have control over the

Fig. 201. — Same as Fig. 200, but three days older. Just moulted.

muscles of this horn, moving it vigorously forward or backward, curling or uncurling it. What is the horn for?

The caterpillars grow rapidly, sometimes changing color until they are dark brown. When less than half grown,

Fig. 202. — Full-grown Pandorus larva in pugilistic attitude. Green (or brown); oval cream-colored spots on the sides, eye-like spot in place of caudal horn. Natural size. Drawn from life.

at one of the regular moults the caudal horn disappears and there is left in its stead a large eye-like spot with a

FIG. 203. — Pandorus chrysalis, in front and side views. Smooth and shining brown. Natural size. Photographed from life.

black center. When full-grown (Fig. 202) the caterpillar is very large and fleshy and three or four inches long. It is seldom in sufficient numbers to do much injury to its food plants.

The shining brown chrysalis (Fig. 203) is made underground. The moth comes forth in June, and words cannot do justice to its beauty. Its wings show the height of artistic blending of harmonious shades of olive green, gray, brown, and rose (Fig. 204). It is one of the most magnificent bits of color work in nature or in art.

The Pandorus has the habits of the majority of Sphinxes, flying at dusk and using its long proboscis to get the nectar from the flowers it likes best.

A caterpillar that is very common

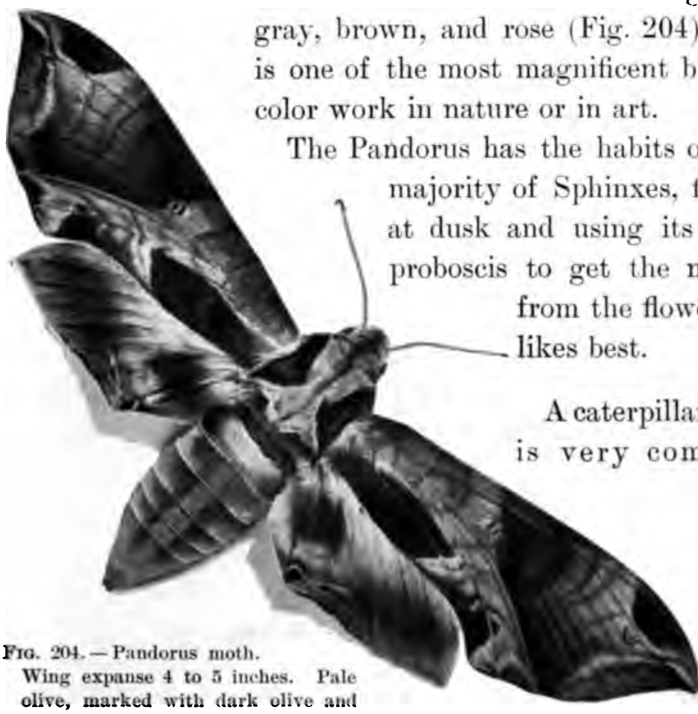


FIG. 204. — Pandorus moth. Wing expanse 4 to 5 inches. Pale olive, marked with dark olive and black. Inner margins of wings show delicate shades of yellow and rose color. Natural size. Photographed from mounted specimen.

in July and August on grape and Virginia creeper (Fig. 205) is the so-called "HOG-CATERPILLAR OF THE VINE."[1]

At maturity it is two inches long, green in color, with a white stripe on each side extending from the straight caudal horn to the head. Below this white stripe are seven oblique white lines, and along the middle of the back there are seven pink spots set in pale yellow. The head is small, and the first two segments are small, so that they may be withdrawn into the swollen segments following, giving the abrupt appearance of the head end so conspicuous in the larva of Pandorus. Sometimes we may find a caterpillar of this species which is brownish pink in color.

FIG. 205. Young "Hog-caterpillar of the Vine" on Virginia creeper. Green; white stripe on each side from caudal horn to head; oblique white lines on sides. 2 inches long when adult.

These caterpillars are very greatly subject to parasites, and it is no unusual thing to see them on the Virginia creeper or grape leaves, covered with the small cocoons of their enemies.[2]

[1] *Everyx myron* (Ev'er-yx my'ron), or *Ampelophaga myron* (Am-pe-loph'a-ga my'ron).

[2] What Ails Him? Gibson's "Eye Spy," pp. 238-246.

The chrysalis (Fig. 206) is lighter brown than are most Sphinx chrysalides. It is not formed in the ground, but within a rudely constructed cocoon on the surface of the ground among the leaves.

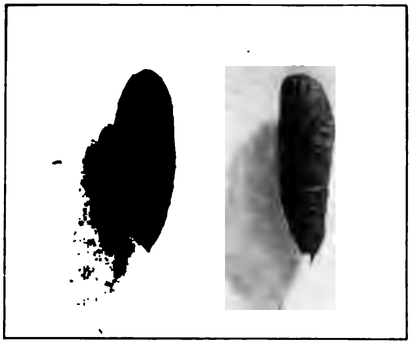


FIG. 206. — Chrysalis of the "Hog-caterpillar of the Vine." Natural size. Photograph.

The moth measures two and one-half inches from wing tip to wing tip. The foundation colors of the body and fore wings are olive green and gray; the hind wings are orange-red.

Another extremely common Sphinx caterpillar is the PURSLANE SPHINX, or the larva of the WHITE-LINED SPHINX MOTH.[1] As its name indicates, it feeds on purslane; but it feeds also on very many low-growing plants, as well as on apple, grape, Virginia creeper, currant, etc. It is most commonly found on the ground in September and October, for it often travels far before finding a spot just to its liking where it may burrow for its winter home. However, "the spot just to its liking" seems queerly chosen at times, for the caterpillar may walk long distances over soft earth only to try finally to force its way down among the stones of a gravel walk.

When full-grown the caterpillars are three inches long and vary greatly in coloring and markings. There seem to be two styles of dress; one is yellowish green with a series of connected spots along each side of the back,

[1] *Deilephila lineata* (Dei-leph′i-la lin-e-a′ta).

each spot being colored crimson, yellow, and black; the other dress is black, with a yellow line down the middle of the back, and yellow spots of various sizes along the

Fig. 207 Larvæ of the White-lined Sphinx (half grown). Green variety at right; black variety at left. Caterpillar at left in typical pugilistic attitude. Photographed from life.

sides. These two styles may be varied in many ways (Fig. 207).

When disturbed the Purslane caterpillar thrusts its head around at one side until it touches the posterior

end and holds itself rigidly in this position; if the disturbance continues, the caterpillar becomes most pugilistic, throwing itself from side to side with all its strength. I have seen robins frightened away from it by this behavior. However, its parasitic enemies are not so easily made afraid. The ranks of the Purslane Sphinxes are kept thinned by these parasites.

FIG. 208.—Chrysalis of the White-lined Sphinx in front and side views. Natural size. Photographed from life.

As has been said, the caterpillar ploughs down into the ground in the late fall; there it moults its skin to form a long and slender light-brown chrysalis, tapering towards both ends (Fig. 208). This chrysalis remains below ground in its snug house all winter; in June it works its way to the surface, and the moth escapes.

This moth is very beautiful; it scarcely seems possible that it is our disagreeable pugilistic Sphinx caterpillar grown older (Figs. 191 and 209). The body and fore wings are olive brown; the hind wings are black, with a central band of rose color. Each fore wing is veined with white and has a conspicuous band of buff extending from the posterior point of its base to its apex. The thorax bears three parallel white stripes on each side, the abdomen has black and white spots in longitudinal rows. As in all the Sphinx moths, the wings are folded over the body in a sloping position. The antennæ are club-shaped; the proboscis is remarkably developed. This Sphinx differs from others in the fact that it very often flies at mid-day.

FIG. [illegible]. White-lined Sphinx moth, fifteen minutes after leaving chrysalis, and just before the wings are folded roof-wise over the body (the natural position in the Sphinx group; refer to Fig. 191). [illegible] Photographed from life.

Especially if the day be a dull one, it may be seen hovering over the flower beds of the garden with the day-flying butterflies and bees.

> . . . Soft moths that kiss
> The sweet lips of flowers, and harm not.
>
> SHELLEY

Part III

RELATIONSHIP

PRACTICAL SUGGESTIONS

A CHAPTER ON RELATIONSHIP, SHOWING CLASSIFICATION[1] AND ANCESTRY OF MOTHS AND BUTTERFLIES

The Four-footed Butterflies or Nymphs.[2] — We know the Monarch butterfly (Fig. 1) very well indeed. It has a long slender body, wings that are folded above the back when it is resting, and thread-like antennæ with knobs at their ends. It is a lover of sunshine, flying only in the daytime. Its wings display great contrast of color. Its chrysalis is naked (Fig. 19), unprotected by any covering whatever. *Its front pair of legs is greatly reduced in size so that at first sight it seems to be only "four-footed." The chrysalis hangs head downward suspended from a button of silk.*

In our study of butterflies we have found others with just the same characteristics. It is certain that this same description would be true of the Red Admiral (Fig. 75); of the Painted Beauty (Fig. 69), and of the Mourning Cloak (Fig. 61); of the Interrogation (Fig. 77), and Comma; of the Viceroy (Fig. 28), and the Red-spotted Purple (Fig. 90); of the Meadow-browns and many others. Because of these likenesses in detailed points which show

[1] The classification of moths and butterflies is based almost wholly on the veining of the wings. A consideration of the subject is out of place in this book. Those who wish to do special work on classification are referred to Comstock's "Manual for the Study of Insects" and other books written for more advanced students.

[2] Family *Nymphalidæ* (Nym-phal'i-dæ).

very near relationship, these butterflies are grouped together and called the "Four-footed butterflies."

All the butterflies of the family are large or of medium size and are of great beauty. *The caterpillars are cylindrical and usually have fleshy or horny projections* (Fig. 7). *The chrysalides as a rule are very angular, with prominent projections.* The members of this group live through the winter in some other form than the chrysalis. The Monarch goes south. The Mourning Cloak, the Painted Beauty, and others hibernate, and so are among the first butterflies to appear in the spring. The Sovereigns (Viceroy, etc.) live through the winter as young caterpillars in snug silk-lined winter houses constructed from leaves of the food plant (Figs. 88 and 89).

These Four-footed butterflies form the largest family of butterflies, and probably the oldest and most highly specialized. Most of the fossil butterflies that have been found belong to this family. It is the best group in which to study protective race instincts.

The Gossamer-winged Butterflies.[1] — There are two very small butterflies that we must all know, the American Copper, which we can see in hundreds on the wild asters in summer and fall, and the Spring Azure, that fills us with as much delight in the early spring woods as do the blue hepaticas. These butterflies will be seen flying only on bright days. They fold the wings above the back when they rest. They have long, slender bodies and thread-like knobbed antennæ. Their colors are very bright, and in the American Copper sharply contrasted. *Their antennæ are ringed conspicuously with white, and there are circles of white about the eyes. The males are*

[1] Family *Lycænidæ* (Ly-cæn'i-dæ).

like the Four-footed butterflies, in that the first pair of legs is undeveloped. The caterpillars are very peculiar, being like small slugs with bodies pressed closely to the leaf on which they are walking. Their legs are very small and short, their heads can be drawn almost wholly within the first segments of the body. They have a gliding movement in walking. *The chrysalides are fastened at the hind end and also by a short girdle of silk that presses them close to their support.*

There are many other small and delicate butterflies of whom this description would be just as true. They are so different from the Four-footed butterflies that they cannot belong to the same family. They form a separate family, called the Gossamer-winged butterflies. The family is a very large one. The Wanderer butterfly, whose larvæ feed on plant lice, is a member of this family.

The Swallowtails and their Allies.[1] — We know still other butterflies. The Black Swallowtail (Fig. 43) has many characteristics like those of the two groups mentioned. It is a day-flier. Its antennæ are long and slender, with distinct knobs at their ends. Its wings are held folded above the back when the butterfly rests. Its body is long and slender. Its chrysalis is naked, unprotected, except by its color and position. However, it differs from the others in that *the chrysalis is supported more or less loosely in a girdle of silk, in addition to the attachment at the hind end* (Fig. 39). *The butterfly has six well-developed legs.*

The Black Swallowtail does not stand alone in answering to this description. There are many others; among

[1] Family *Papilionidæ* (Pa-pil-i-on'i-dæ).

them are the Tiger Swallowtail (Fig. 47), the Zebra Swallowtail, the Cabbage butterfly (Fig. 94), and the Clouded Sulphur (Fig. 91). They form a well-marked family. *The caterpillars are long and cylindrical; they are either naked* (Fig. 29) *or are clothed with a few scattered fine hairs. Many of them are exceedingly peculiar in the possession of a pair of fleshy horns, protruded or concealed at pleasure.* These horns or osmateria (os-ma-te'ri-a) are just back of the head (Fig. 31); judging from their disagreeable odor they are protective.

This family includes some butterflies of medium size, but the majority of them are magnificent both in size and coloring. It includes the Parnassians, butterflies found only on high mountains or at the far north.

How to distinguish Butterflies.[1] — The Four-footed butterflies, the Gossamer-winged butterflies and the Swallowtails and their allies, all agree in a few very definite characteristics. *They have naked chrysalides*, usually resembling bits of stem or bark, placed where this resemblance protects them. *They have long, slender bodies in the adult form; wings that are folded above the back when the butterfly is resting; and antennæ that have knobs at their ends. They display striking contrasts in the coloring of their wings; they fly only in the daytime.* By these characteristics a butterfly can always be distinguished.

The Skippers.[2] — There are a very large number of butterfly-like creatures that are little known to us. Though they are so small, they are very strong of wing and have gained for themselves the name of **Skippers** because *they dart suddenly from place to place. They*

[1] *Rhopalocera* (*rhopalon*, club; *keras*, horn).
[2] Family *Hesperiidæ* (Hes-pe-ri'i-dæ).

are relatively dull in coloring, a fact testified to by such names as Cloudy-wing, Black Dash, Dusky-wing, and Sooty-wing. They are day-fliers. They fold the wings above their backs when in resting position. But see the antennæ! *The knobbed ends are drawn out and recurved to form a crook.* We have never seen butterfly antennæ like these. *The head is peculiarly large, the body is stout. The larvæ are just as peculiar. Their heads are large and are separated from the body by a neck-like constriction* (Fig. 228). This separation is made more striking by the fact that head and body are usually of distinctly different colors, and that the body is largest at its middle and tapers towards the head. We have not yet seen the greatest difference between the Skippers and the butterflies that we know. A strong butterfly characteristic is that the chrysalis is naked, never protected in any way except by its position, its color, and its own hard coat of chitin. Butterfly chrysalides are usually angular also. *The chrysalides of the Skippers are rounded and are protected by thin cocoons.* Yet the Skippers show relationship to the butterflies by having the chrysalis held in place by a girdle of silk and fastened to its cocoon at the posterior end.

Are the Skippers butterflies? Some think so; others separate them because of their striking differences and allow them to stand as a group nearly related to butterflies, but not so nearly related as butterflies are to one another. The Skippers will help us understand the relation between butterflies and moths.

The Giant Silkworms.[1] — The Cecropia moth (Fig. 146) is a common and well-known form over the greater part

[1] Family *Saturniidæ* (Sat-ur-ni′i-dæ).

of the United States. There is a soft blending of the colors of its wings. It has a stout and very hairy body. It flies at night only. *The Cecropia is large and very beautiful. The antennæ of the male are feathered to their tips. The head is small and sunk beneath the thorax. The proboscis is undeveloped, Cecropia taking no food in the adult state, and so living but a short time. The larvæ are large and are provided with tubercles and spines* (Fig. 139). *The chrysalides are smooth and rounded, and are protected by silken cocoons* (Fig. 141).

Promethea (Fig. 115), Luna (Fig. 163), Polyphemus (Fig. 148), Cynthia (Fig. 96), Io (Fig. 124), and still others are like Cecropia in these characteristics. We call them the Giant Silkworms.

This family includes the largest moths of the world. Because of their size and beauty they are perhaps the best known of the moths. They are likely to become at some time in the near future of very great economic value to man, because of their silk-spinning habit. The cocoons vary greatly in the amount of silk in them. Those of Io are very thin, while Polyphemus spins a cocoon containing several hundred feet of silk. Some of the cocoons are closed everywhere, like those of Polyphemus (Fig. 149) and Luna (Fig. 162); others, like Cecropia (Fig. 141) and Promethea (Figs. 108 and 109), are made with an opening for escape at the head end. This group gives a good field for the study of protective race habits of a simple kind.

The Chinese Silkworm (Fig. 168) is very nearly related. It belongs to a group[1] not represented in our country. The Tent caterpillar (Fig. 180) is also very closely allied.

[1] Family *Bombycidæ* (Bom-byc'i-dæ).

The Royal Moths [1] form a very small family very nearly related to the Giant Silkworms, as is indicated by their almost identical structure. They can be distinguished by the fact that *the antennæ of the males are feathered only about halfway to their tips. The chrysalides are formed underground without the protection of cocoons.* The caterpillars of the Royal moths feed on various forest trees,— on maple, oak, hickory, butternut, etc. They are seldom in large numbers. Some of the moths are of medium size (Fig. 229), but others are rivals of the Cecropia in size and beauty.

The Sphinxes, or Hawk Moths. [2]—We are well acquainted with the different stages in the development of the Tomato Sphinx, which is so common wherever tomato, potato, or tobacco is grown or where Jamestown-weed is common. The moth has a stout and hairy body. There is great beauty and harmony in the coloring of its wings. It flies at dusk. *It has long, narrow wings* (Fig. 195) *and is most powerful in flight,* for which characteristic it has received the name of Hawk moth. *Its proboscis is remarkably developed,* and as the moth poises on vibrating wings before the honeysuckles to get the nectar from their deep flowers, we can understand why it has been named Humming-bird moth. *The antennæ are thickened at the middle, and the tip is curved backwards to form a slight hook. The larva is long and cylindrical and has a horn at the hind end of the body* (Fig. 192). *When disturbed it takes the noted "sphinx attitude." The chrysalis is formed underground* (Fig. 193).

These are very striking characteristics. In the main they are true of many other moths. The Purslane Sphinx

[1] Family *Citheroniidæ* (Cith-e-ro-ni′i-dæ).
[2] Family *Sphingidæ* (Sphin′gi-dæ).

(Fig. 191), the Pandorus (Fig. 204), the Twin-spotted Sphinx (Fig. 196), the "Hog-caterpillar of the Vine" (Fig. 205), Thysbe Clear-wing (Fig. 230), and the Abbot Sphinx are so like the Tomato Sphinx that they must belong to the same family.

In one or two particulars they may vary: Pandorus and the Abbot Sphinx, for instance, lose the caudal horn before they are full-grown, the horn being replaced by a tubercle (Fig. 202); the Twin-spotted Sphinx has a poorly developed proboscis; Thysbe Clear-wing caterpillars make thin cocoons among leaves on the ground, instead of burrowing; and in the full-grown Purslane Sphinx caterpillar the defensive position is with the head swung forcibly around to the tail (Fig. 207) instead of the typical "sphinx attitude." The Sphinx family is a very large one. There are about one hundred kinds of Sphinxes known in the United States.

The Tiger Moths.[1] — The small dainty white moth (Fig. 171) of the Yellow Bear caterpillar is a familiar "miller," attracted to our lights at night. It has a stout, hairy body. It flies at night only. *The wings have a few black spots which have caused it to be named "Tiger moth." The antennæ are narrow feathers. The wings are folded like a gable roof over the body.* The caterpillar itself is still more commonly known than the moth. *It has a dense covering of hairs. It can run very fast. The chrysalis is protected by a cocoon made almost wholly from the hairs of the caterpillar.*

There are many moths that answer this description in all stages. Some of the most common are the Woolly Bear (Fig. 169) or Isabella Tiger, the Harlequin Milkweed

[1] Family *Arctiidæ* (Arc-ti'i-dæ).

(Fig. 174), the Hickory Tiger (Fig. 172), the Salt-marsh Tiger, and the Bella moth. The majority of our hairy or "bear" caterpillars belong to the Tiger moths. The Woolly Bear and some others hibernate as caterpillars.

The Tussock Moths.[1] — Very nearly allied to the Tigers are the Tussocks. *The caterpillars are hairy, but these hairs are gathered into distinct tufts*, hence the name of the group. *The larvæ are noted for their gay colors. The moths are plain in color and, as a rule, the females are wingless, so that the distribution of the family is accomplished mainly through wanderings of the caterpillars. The antennæ are feathered in both sexes.*

Our most common representative of the group is the White-marked Tussock (Fig. 182). Probably the best known is the Gypsy moth, that was imported into Massachusetts and has caused so much havoc there. Any imported species will leave at home its natural enemies, parasitic and otherwise, and so is likely to thrive and become a pest.

The Owlets.[2] — There are large numbers of small moths, or "millers," that fly into the house at night and hover about the lights. Many of them are the same ones that fly out from under our feet as we walk through the meadow. They have stout bodies in proportion to the size of their wings. They fly only at night. *As a rule they are very dull in coloring. They fold the wings roof-wise over the back when resting. Usually the antennæ are thread-like, not feathered.* They are called Owlets, because of their shining eyes and their habit of flying at night only. They form a very large group, the largest family among

[1] Family *Lymantriidæ* (Ly-man-tri′i-dæ).
[2] Family *Noctuidæ* (Noc-tu′i-dæ).

moths and butterflies. There are over eighteen hundred kinds known in America north of Mexico.

The family is far-famed over the country, because of the depredations committed by the larvæ of various of its members. All the Cutworms belong in this family — the caterpillars that vex the agriculturist and gardener so greatly by cutting off near the ground the stems of young plants in the spring. The notorious Army-worms, that occasionally become so numerous that they travel in great hordes from one place to another, devouring everything in their way, also belong to the Owlets. The family contains also the Bollworm and Cotton-worm, that cause so much havoc in the cotton fields at the south. The yellow Zebra caterpillar, conspicuously striped lengthwise with black, is commonly known on cabbage and other vegetables, but is seldom in large enough numbers to do much damage.

The most interesting of the Owlets are the so-called Underwings.[1] They are not so well known as others because the larvæ feed on forest trees instead of on cultivated plants. The moths of the Underwings have most beautifully and brilliantly colored hind wings which are wholly "under" the dull fore wings when the moth is in resting position (Figs. 210 and 211). We may look very closely at these moths as they are resting on the bark of the hickory or oak and not have a suspicion that they are there, so remarkably are they colored like their surroundings. Sometimes they may be found on the undersides of fence rails and under bridges. The Tussocks are very often included in this family.

[1] *Catocala* (Ca-toc'a-la).

The Prominents.[1] — Nearly related to the Owlets is a group of medium-sized moths known as Prominents. They resemble the Owlets in most characteristics. Some have on each fore wing a backward-projecting prominence that has given them their family name. The name is better deserved by the larvæ, many of which are grotesque with curious humps and projections. They feed mainly on forest trees. The Yellow-necked Apple-tree-worm and the Red-humped Apple-worm are two most commonly known, because they feed on apple and cherry (Figs. 188 and 189).

The Loopers, or "Measuring-worms."[2]—We have always known the "Measuring-worms," or "Inch-worms," that measure the ground by inches as they walk. *They are long and slender, and lack the prolegs near the middle of the body, so must walk with a looping motion. The moths are small or of medium size. Their wings are very delicate, owing to the smallness of the scales covering them; they are spread horizontally when the moth is resting.*

These moths are common along the borders of woods and in open groves. The Scallop-shell moth is a Measuring-worm. The Currant Span-worm is a yellow looper that sometimes does damage to the currant and gooseberry bushes, although the best known Currant-worm is the larva of a saw-fly. (It has more than the five pairs of prolegs of the ordinary caterpillar, instead of fewer.)

However, the pests of the group are the spring and the fall Cankerworms. They are frequently known to strip the leaves from various fruit and shade trees. The female moth is wingless. The chrysalis is formed

[1] Family *Notodontidæ* (No-to-don'ti-dæ).
[2] The Geometrids (Ge-om'e-trids).

in the ground, at the bases of the food trees. We can understand from the last two facts the purpose of the strips of tarred paper that we have seen about the trunks of trees. A girdle of any sticky substance will prevent the females from climbing the trunks of the trees from the ground to the leaves to lay their eggs, and they cannot fly up to the leaves. If the eggs are laid below, the little caterpillars cannot climb over this barrier.

The Leaf-miners.[1] — There is a group of *extremely small moths whose narrow wings are bordered with soft fringes. They are often of great beauty, being covered with gold and silver scales.* They are so small that we need a hand lens to see them satisfactorily. Many of them are so very minute that *their larvæ live until full-grown in the thin blade of a leaf between the skin of the upper surface and that of the lower surface.* Because of the habit of mining in the pulp of a leaf they are called Leaf-miners.

The mines that they tunnel out vary greatly in shape. They may be long and twisted, gradually broadening towards the end (showing the growth of the caterpillar), hence called serpentine mines. They may be rounded or irregular light-colored blotches (blotch mines), so conspicuous on many kinds of leaves in summer and autumn. Others are like the serpentine mines, except that they are much shorter and broaden more rapidly; these are called trumpet mines.

The Oak-leaf miner is common on many kinds of oak, forming blotch mines. The Apple-leaf Trumpet-miner forms trumpet mines on apple leaves. No one can see the Leaf-miners in their snug galleries without thinking that they must be what Lowell referred to when he said:

[1] Tineids (Tin'e-ids).

"And there's never a leaf nor a blade too mean
To be some happy creature's palace."

The family of the Tineids is a very large one, and probably not half of the number belonging have been discovered and named. In many cases the caterpillars of the fall brood hibernate in their mines; therefore if they become a pest they can be destroyed by burning the fallen leaves.

The varieties of moths whose larvæ feed on clothes belong to the same family as the Leaf-miners. Garments can be kept from them during spring and summer by careful wrapping in paper.

The Leaf-rollers.[1] — Very nearly related to the Leaf-miners are the Leaf-rollers. They are extremely small moths and to appreciate the beauty of their perfect structures and their golden and bronze coloring we need a lens; but they are considerably larger than the Leaf-miners. *The front wings are broad and end squarely, and all four wings are folded roof-wise over the body when the moths are resting. Most of the larvæ live in nests made by rolling leaves.* They may be solitary, or they may live in large colonies in a nest made of many leaves. The Cherry-tree Ugly-nest caterpillar is of the latter kind (Fig. 175).

In the family with the Leaf-rollers is the Codlin moth, whose larvæ we find feeding at the core of wormy apples. The eggs of this moth are laid in the heart of the open apple flowers. When the eggs hatch, the caterpillars eat their way into the young apples. Fruit-growers destroy the Codlin moth by spraying the trees with Paris-green water at about the time that the petals

[1] Tortricids (Tor′tri-cids).

fall from the apple flowers. The first meal that the little caterpillar eats is then a poisoned one.

The Slug-caterpillar Moths.[1]—There are still many other types of moths. Among them are the Slug-caterpillar moths. *The larvæ of these can be recognized by their gliding, slug-like movements, brought about by the fact that the caterpillar has extremely minute legs. The head can be drawn within the first segments of the body so that it cannot be seen.* The brown and green Saddle-back caterpillar is one of the curious members of the group. Its name describes it. This caterpillar feeds on oak, ash, barberry, and many other trees and shrubs.

How to distinguish Moths.[2]—If we consider all the groups of moths that we know, we feel that their relationship is very near, and yet it is difficult to select definite points of likeness. *They fly at night or at dusk. They have stout, hairy bodies. Their wings show softly blended colors.* They are most easily distinguished by negative characteristics. *They never have thread-like antennæ with knobs at the ends, and they do not fold the wings above the back when resting.* The antennæ may be thread-like or feathered; they may be thickened at the middle or gradually thickened toward a recurved tip. The wings may be spread horizontally in resting position or folded roof-wise over the body, or possibly rolled around the body. *The chrysalis is never naked and angular, as it is in butterflies. It is rounded and is protected by some outside covering.* Most moth caterpillars build cocoons; these may be wholly of silk, of silk and the hairs from the caterpillar's body, or of silk and bits of wood or

[1] Family *Eucleidæ* (Eu-cle'i-dæ).

[2] *Heterocera* (*heteron*, other; *keras*, club; other than club-shaped).

bark. Many moth caterpillars burrow into the ground or make tunnels in wood when the change to the chrysalis form approaches.

Adaptation for Life in a Chosen Haunt.—We have found that, although fundamentally all butterflies are alike, all moths are alike, and all butterflies are like all moths; they differ nevertheless in detailed points so much that they not only fall naturally into families, but that members of their families vary greatly among themselves. Let us see if we can find out any of the causes that have produced these differences in creatures so nearly related.

We have found moths and butterflies most wonderfully adapted for the lives that they lead. They have "tongues" just the right length to get the honey from their chosen flowers. The caterpillars have mandibles just the right strength to eat the tough leaves of the oak or the tender leaves of the milkweed. The caterpillars spin cocoons just the right thickness to protect them from changes of temperature during winter in their exposed or in their hidden positions. They seem perfectly adapted for the given conditions.

However, it is always possible that these conditions might change gradually or suddenly. If a blight or other cause should kill out the tubular flowers on which some long-tongued moth feeds, or they should be cultivated no longer (if cultivated plants), these moths might die out. But these moths are not exactly alike among themselves. Some few of the shorter-tongued of the race might "learn to like" the nectar of some other flowers with shorter tubes, or a very few of the strongest and most vigorous and longest-tongued might, by pushing the

head far into the flower, get the nectar from some deeper flower. But this single change in conditions most probably would mean other changes. These two new food plants might grow in very different locations more or less exposed, might be very differently colored from the first food plant, so that the light and heat effects would be different. It is easy to see that those moths that could adapt themselves to the new food conditions in the two cases might not be able to live because of other disadvantageous conditions. Those best adapted for the new conditions would live, the others would die.

FIG. 210. — An Underwing moth (*Catocala concumbens*) in resting position. Protected by resemblance to bark of tree. Natural size. Photographed from Denton mount. (Compare with Fig. 211.)

Now we have only to suppose that these new conditions should be more or less permanent for many generations in succession, and we have two moths varying considerably from the original form. For in any one generation there will be some stronger moths better adapted to the new conditions than others. These will survive and will send on to some of the next generation the characteristics that adapt them to the new conditions.

It is easy to understand that since a moth or butterfly must be well adapted for its life (or it will die for lack of food or other requirement, or will be killed by enemies), since structural characteristics and instincts are carried on from one generation to another, and since the conditions surrounding any kind of moth or butterfly are not

permanent, but change either gradually or suddenly with relative permanence following, there must slowly come about through ages of life detailed differences among moths and butterflies.

Protective Resemblance and Mimicry.—Nature's law, that a moth or butterfly must be well adapted for its life in its chosen home, is most interestingly worked out along the lines of shape and color. Every creature has a hard fight in life, not only in getting the right kind of food and a comfortable home to live in, but in protecting itself from its many enemies. Moths and butterflies, in all stages of their development, have many enemies that prey upon them. Those that can best escape observation from their enemies are the ones that will be most apt to live. Therefore, those looking most like their surroundings, either in color or form, so that they are inconspicuous except when moving, will be the ones to escape their enemies. In any one generation these more protected forms are the ones that will live; and this is true not only in one generation, but is the working law throughout ages of generations. Are we surprised that we have gray moths that cannot be distinguished from the gray tree trunk or from weather-beaten boards on which they rest (Fig. 210)? small green and white moths that

FIG. 211.—Underwing moth (*Catocala concumbens*) in position when flying. Upper wings gray, under wings brilliant with carmine and black. Natural size. Photographed from Denton mount. (Compare with Fig. 210.)

resemble bits of lichen on tree trunks? large brown butterflies and moths that deceive us, as well as birds and other enemies, by their close resemblance to brown leaves? The large green Luna moth rests amid the hickory leaves and is invisible. Antiopa and other brown butterflies look like fragments of brown leaf or bark.

Many moths and butterflies have bright bits of color, possibly for attraction or recognition of one another; but, as a rule, these bright colors are displayed only during flight,

FIG. 212. -- Kallima, a "Leaf-butterfly" of India. In flying position. Wings brilliant with iridescent black, orange, and blue coloring. Slightly reduced. Photographed from Denton mount. (Compare with Fig. 213.)

and are covered by dull-colored parts when the moth or butterfly is resting. Moths that fold the wings roof-wise over the body may have the under wings bright in

color, as in Io (Figs. 123 and 124) or Catocala (Figs. 210 and 211). Butterflies have the upper surfaces of the wings bright-colored; the under surfaces, displayed when the wings are folded above the back in resting position, are protectively colored (Figs. 212 and 213).

FIG. 213. — Kallima in resting position. Protected by resemblance to brown leaf. Photographed from Denton mount. (Compare with Fig. 212.)

This protection of a creature by resemblance to its surroundings is a thought that, if followed out in observation, leads one into constant surprises and discoveries. It is difficult to see green caterpillars on their green food plants. We know the brown and the green Loopers that have the habit of standing out stiffly from a branch, fastened by the hind prolegs only, so that they look like small twigs or leaf stems. This likeness of a creature in form or color to the inanimate objects around it is called protective resemblance. The examples of it are endless.

Some moths and butterflies are protected by their close resemblance to other moths and butterflies which have poisonous or nauseous qualities, so that birds and other enemies will not eat them. Our best illustration is the Viceroy, which deceives its enemies by its resemblance to the poisonous Monarch (Figs. 1 and 28). This close resemblance of an unprotected form to one that is protected is called mimicry. The word is unfortunately chosen, in that a mimic usually knows of, and plans, his mimicry. The Viceroy is a perfectly unconscious actor in this case of mimicry. Nature has done the work. The butterfly probably had a slight resemblance to the Monarch in the beginning. The members of any given brood would vary somewhat. Some would have slightly wider bands of black, perhaps, or more of the orange-brown color. These the birds would confuse with the Monarch and, hence, leave them undisturbed. The others would be killed. Supposing this first slight resemblance true, there is needed to produce as perfect a case of mimicry as represented by the Viceroy only proximity to the poisonous form and a space of many generations through which can be sent these color characteristics, always becoming more and more like those of the butterfly mimicked.

We can understand that protective resemblance and mimicry, which are the results of the law that in order to live at all, creatures must be well adapted for life in their chosen environments, explain some of the striking differences between various moths and butterflies, since their environments must differ so greatly.

Dimorphism. — It is found that when a butterfly has two broods in a season, the adults of these broods are

apt to differ considerably from each other. These differences are in form and color, and are probably due to the different heat effects of the seasons. In fact, it has been proved that butterflies of the summer brood kept in a refrigerator during development will be like those of the spring brood, when otherwise they would be very different. This difference of form and color in the two broods of a butterfly is termed "dimorphism." If there are three or more broods and three or more different forms, the variation is termed "polymorphism."

We know two distinct forms of the Interrogation butterfly and two of the Clouded Sulphur. The little Spring Azure is said to have nine or ten different forms. One of the most noted cases is that of the Zebra Swallowtail. It has three distinct types. The butterflies that come from their chrysalides early in spring are small and form the spring type. Some remain in the chrysalis state till later. These are larger butterflies, called the late spring type. Those that come from eggs laid during the summer season are largest of all, forming the summer type. The three types of the Zebra Swallowtail vary not only in size but have slight differences in coloring also.

It is not difficult to see that variations that are the direct results of climatic differences and changes may have helped greatly in bringing about the present condition of things, in which we have many different kinds of butterflies and moths.

Dimorphism, not seasonal, exists among caterpillars. Protectively colored caterpillars are very likely to show two distinct types of dress based on the two chief colors of nature — green and brown. This variation must give any race showing it double security against enemies.

A SYNOPSIS OF COMMON BUTTERFLIES AND MOTHS

Euploeids (Monarch)		
Crescent-spots		
Fritillaries		
Angle-wings	Four-footed butterflies	
Emperors		
Sovereigns		
Meadow-browns		
Coppers		
Blues	Gossamer-winged butterflies	Butterflies
Hairstreaks		
Pierids		
Swallowtails	The Swallowtails and their allies	
Parnassians		
	The Skippers	
	Giant Silkworms	
	Royal moths	
	Sphinxes (Hawk moths)	
	Tiger moths	
	Tussock moths	Moths
	Owlets	
	Prominents	
	Loopers	
	Leaf-miners	
	Leaf-rollers	

Fundamental Likenesses among Moths and Butterflies. — We have become acquainted with several moths and with several butterflies. We have traced their development from the egg through the whole cycle of their lives to the egg again. We have found that, although they differ in certain detailed respects, on the whole they are remarkably alike. We should be able to recognize one anywhere, not only in the adult winged form, but also in the larval and the pupal (chrysalis) stages: and not only should we be able to recognize

it, but we should be able to tell pretty accurately about its development from the egg, and we should know many of its habits.

Likenesses in the Development of Moths and Butterflies. — We are familiar with the fact that all living creatures develop from eggs. We know the hen's eggs, and the mother hen with her brood of downy chickens. We have found the turtle's eggs in the sand of the river bank, and we know the little turtles no larger than a small silver piece. Moths and butterflies develop from eggs (Figs. 6, 80, and 134), but they do not look like moths and butterflies when they hatch from the eggs. They are only partially developed and come out to get food. We call them caterpillars, or larvæ of moths and butterflies. The caterpillar eats and grows, finally attaining a size that is usually considerably greater than that of the adult butterfly or moth. During this growth the horny skin (chitin) covering the caterpillar is shed at least three times (Figs. 103–105). Finally, after a growth of ten days or more, the caterpillar stops eating and finds some sheltered place. Here the skin is again shed (Figs. 15–17 and 52–54), and a strange creature is revealed — the chrysalis or pupa (Figs. 19 and 55). This sleeping stage, in which the moth or butterfly is bound in a perfectly helpless condition, lasts ten days or more. It may be the winter state. During this time no food is taken. That stored up during the caterpillar stage serves for development. At last the growth is perfected, and the chitinous skin is shed once more (Figs. 21–24). This time it is the adult moth or butterfly that crawls out from the case. Its wings soon expand and dry; its chitinous coat hardens, and the moth or butterfly is

ready for life (Fig. 26). *There has been a complete change of form, with the occurrence of a quiescent or sleeping stage between larva and adult. There has been a complete metamorphosis.*

Structure Common to all Caterpillars. — Caterpillars are remarkably alike in structure, and this structure is very simple. They are long and slender, with bodies distinctly divided into twelve segments (Fig. 9). There is a distinct head, and the right and left sides are alike. They are protected by thin coverings of chitin. The head is provided with simple eyes, with strong mandibles for cutting the leaves, and with a spinneret (Fig. 11). There are also two minute antennae that become the antennae of the adult, and two small maxillae below the mandibles which develop into the sucking proboscis of the moth or butterfly. Each of the first three segments has a pair of short jointed legs, the "true" legs; each of the sixth, seventh, eighth, ninth, and twelfth segments has a pair of fleshy prolegs,[1] which exist only during the caterpillar life. Caterpillars breathe by means of air tubes (tracheae) that penetrate to every part of the body. These tubes open to the exterior through spiracles on the sides of the caterpillar. Each segment, except the second, third, and twelfth, has one pair (Fig. 9). Undeveloped wings lie concealed under the skin of the second and third segments.

Structure Common to all Chrysalides of Moths and Butterflies. — If we compare the chrysalides of all the moths and butterflies that we know, we find that they are all alike, not only in the fact that they are absolutely helpless, but also in that they show with more or less

[1] The Geometrids lack the prolegs near the middle of the body, so walk with a looping motion.

distinctness the parts of the sleeping moth or butterfly (Figs. 20, 114, and 142). They are usually brown. On the back can be counted the twelve segments that were seen in the caterpillar. The first segment has a pair of spiracles; the second has the first pair of wings attached to it; the third has the second pair of wings. These three segments are the thorax of the moth or butterfly. The remaining segments form the abdomen. They bear the rest of the spiracles. The wings are wrapped from the back to the front, as a cape is folded about a person. Lying close to the surface down the front of the chrysalis are the two parts of the proboscis, the antennæ and the legs. Movement is limited to the abdominal segments. The prolegs of the caterpillar have wholly disappeared. The mandibles have sunk into insignificance. The wings, the long proboscis (the maxillæ of the caterpillar), and the antennæ have become very conspicuous.

Similar Structures in all Adult Butterflies and Moths. — Moths and butterflies are greatly alike in general appearance, as well as in many details of structure. There is a distinct division into head, thorax, and abdomen. The head is supplied with large compound eyes, with a pair of antennæ, *and with a long sucking proboscis,*[1] *which is wound into a close coil, like a watch spring* (Fig. 5). The thorax has two pairs of wings[2] on the back. On the underside it has three pairs of jointed legs adapted for clinging. The whole body is covered with chitin, and over this is a coat of soft hairs. The wings are of transparent chitin, with a tracery of so-called veins (Fig. 3),

[1] The proboscis may be undeveloped, or even lacking, as in the Giant Silkworms.

[2] In exceptional cases the wings are lacking in the female, as in the White-marked Tussock, Bagworm, etc.

and *are covered above and below with overlapping colored scales*. The abdomen is segmented. The structures for breathing — spiracles and tracheæ — are just the same as in caterpillars, and with the same relative positions.

Habits Common to all Butterflies and Moths. — Butterflies and moths have many habits in common. These habits must tell something of their relationship to one another, because habits are so closely connected with structures. Butterflies and moths always place the eggs on the plant which is the food plant for the young caterpillars. The caterpillars eat their way out of the eggs (Figs. 134 and 157) and usually devour the shells down to the leaf. All caterpillars eat the green leaves of their food plants,[1] using the "true" legs as hands to aid in managing the leaves (Fig. 102). All caterpillars moult the chitinous skin several times during their growth, and always by exactly the same method (Figs. 103–105). Hiding is the great protection in caterpillar world, although some caterpillars have special means of protection as poisonous qualities, nauseous odors, or a covering of branched spines or thick hair. The adult butterflies and moths take only liquid food, getting their supply from the nectar of flowers and the juices of fruits (Fig. 28).

Both in the larval stage and in the adult they have highly developed instincts which prompt them to accomplish wonderful feats for their protection. Some build nests of leaves in which to conceal themselves; some spin cocoons with openings above their heads ready for escape.

[1] The caterpillars of the Wanderer butterfly (*Feniseca tarquinius*) feed upon plant lice. They can be found on alder stems covered with the white-alder aphis. The Clothes moth is another exception.

They may fasten cocoons firmly to branches so that they do not fall to the ground (Fig. 97). Others may cut away leaves to just the best size and shape for the construction of winter houses (Fig. 83), and then fasten these houses to twigs by means of silk (Fig. 89). The adults may play dead when caught (Fig. 62). There are innumerable instances in which moths and butterflies perform acts for their protection which seem to argue intelligence. These acts are the results of high instinctive powers.

Near Relationship of Moths and Butterflies to Each Other. — When we see that moths and butterflies have so many points in common in their development, in their structure, and in their habits, we do not question their near relationship. They form a very distinct group in the world.[1] We should never mistake them, no matter in what country we found them, and they are very common all over the globe, being most numerous in tropical South America and Africa. In Mexico one may find from fifty to one hundred different kinds in one day out of doors. There are about twenty-five thousand known kinds of butterflies in the world and many more moths, so that the group is not only a very distinct one but a very large one also.

Relationship to Ants, Bees and Wasps.[2] — Although butterflies and moths form so distinct a group with its members so closely related to one another, if we look about us we find many creatures that are greatly like them in development, in structure, and in habits. The ants, bees and wasps correspond exactly to the moths and butterflies in their growth from the egg. *They exist in four forms — in the egg, larva, pupa, and adult stages, the pupa being a*

[1] Order *Lepidoptera* (Lep-i-dop′te-ra — *lepis*, scale ; *pteron*, wing).

[2] Order *Hymenoptera* (Hy-me-nop′te-ra — *hymen*, membrane ; *pteron*, wing).

perfectly helpless quiescent stage (Fig. 119). *The metamorphosis is complete.* However, the larva is a much more helpless creature in this group than in the moths and butterflies. It never moves from the place in which it hatches from the egg.[1] There may be plenty of food at hand stored up in the cell in which the larva finds itself, or it may be fed carefully by adults who constitute themselves nurses. Before the change to the pupal stage some of them spin cocoons about themselves, as do some of the moth caterpillars.

The ants, bees and wasps are wonderfully like the moths and butterflies in general structure. Let us look at them carefully (Figs. 121 and 122). They have the same covering of chitin and the same divisions of the body (head, thorax, and abdomen). They have the same number (three pairs) of jointed legs on the underside of the thorax. On the back of the thorax they have two pairs of wings. These are of transparent chitin with veins traversing them. The abdomen is segmented and provided with spiracles. The head has compound eyes, a pair of antennae, and a sucking proboscis. So far they are just like moths and butterflies. *However, they have no colored scales on the wings; the proboscis is never long enough to be coiled as it is in moths and butterflies; and in addition to this sucking proboscis there are strong mandibles for biting. Some of them are provided with stings. They are always small or of medium size.*

Because of all the marked likenesses of the moths and butterflies on the one hand to the ants, bees and wasps

[1] The saw-flies are members of this group and exceptions to this. Their larvae are very much like caterpillars and move about independently, getting their food as do caterpillars.

on the other, likenesses in development and likenesses in structure, they must be very nearly related to each other; but they are not as nearly related as the members of the group of moths and butterflies are to each other. They lack certain characteristics — notably the scales on the wings; they have additional characteristics — conspicuously the mouth adapted for biting as well as for sucking. As a result of these differences they form a distinct group.

Ants, bees and wasps show relationship to moths and butterflies in that they also represent the most wonderful development of instinctive powers. There have been volumes written on them, and there are still volumes to be discovered about even our most common forms. They may live in colonies and have their numbers divided into bands to do different kinds of work. They may dig a perfect labyrinth of connected chambers underground and use them as a home. They may make a waxen comb of perfectly regular cells as homes for their young or as storehouses for food. They may build symmetrical mud nests and store up in the cells paralyzed caterpillars, grasshoppers, or spiders for their young to feed on. They show most wonderful instincts for caring for their young and for storing up food for winter. The ants are said to be able to communicate ideas to one another by means of their antennæ. Much that has been found out about this group reads like a fairy story. It is a field where we can all go on a tour of discovery because the material is so common.

The group includes not only ants, bees and wasps, but in addition the saw-flies whose larvæ are caterpillar-like and feed on leaves, the gall-flies whose larvæ live in

outgrowths or galls (oak-apples, etc.) on oak, rose, and various plants, and ichneumon flies whose larvæ are parasitic within the bodies of larvæ of the members of other groups.

Relationship to Flies.[1] — Here again the development shows the same four stages, the larva being a very different creature from the adult. *The pupa is a helpless sleeping form; the metamorphosis is complete.* If we examine a fly, a gnat, or a mosquito, we find in general exactly the same structure that we have seen in moths and butterflies. Again the relationship must be very close. *However, flies have only two wings, and these are membranous, without scales. The sucking proboscis is not long enough to be coiled as it is in moths and butterflies.* Their instinctive powers are of a much inferior order. So again we have nearly related to moths and butterflies a very distinct group. This group includes not only the house-fly, gnats and mosquitoes, but crane-flies, robber-flies, horse-flies, and many others — but by no means all the creatures that are called flies.

Relationship to Beetles.[2] — During a day spent in the country in summer we shall see — if we look for them[3] — not only moths and butterflies, ants, bees and wasps, and flies of all sorts, but a great many other small creatures that many of us know. As we walk along the dry sunny path, bronze tiger-beetles fly out from our feet or run on ahead of us very fast indeed. The low willow by the side of the road has large goldsmith-beetles on it, and we stop

[1] Order *Diptera* (Dip'te-ra — *dis*, two; *pteron*, wing).

[2] Order *Coleoptera* (Co-le-op'te-ra — *coleos*, sheath; *pteron*, wing).

[3] Many an object is not seen, though it falls within the range of our visual ray, because it does not come within the range of our intellectual ray. So in the largest sense we find only the world we look for. — THOREAU.

to admire their shining coats. We lift a stone and find long brown click-beetles or "snapping-bugs." We turn them on their backs to hear them "click" and to see them right themselves so easily. Something very small flies toward us. It alights on our sleeve, and there is a red-backed, white-spotted "lady-bird." If we look sharply, we may see a pair of "tumble-bugs" industriously rolling a ball along the road. Let us follow and watch and find out how they get it buried so far underground. They do not dig a hole and roll it in, as we should expect them to. As we pass over the brook we see a whole colony of whirligig-beetles or "lucky-bugs" whirling about on its surface. Towards night the fireflies begin showing their lights, and the great brown May-beetles, or "June-bugs," and the black stag-beetles, or "pinch-bugs," come blundering and buzzing into the house, making a great noise as they strike against the wall or floor.

If we examine one or all of these we find, much to our surprise, that here again are the characteristics we know so well in moths and butterflies. *However, there is no sucking proboscis; instead, the mouth-parts are fitted for biting. There are only two wings, the hind wings; these are membranous, without scales. Most curious is the fact that the position of the fore wings is taken by a pair of thick and horny wing covers.* These wing covers meet down the mid-line of the back of the beetle and usually just fit over the body.

The development is a complete change of form, as it is in moths and butterflies. The larva is called a grub. It lives underground or in tunnels which it makes in wood or possibly exposed on the leaves of a food plant, as in the

case of the "potato-bug." The time for development varies greatly, sometimes several years being needed for the growth from the egg to the adult. There are over one hundred thousand kinds of beetles known to man.

Relation of Moths and Butterflies to Grasshoppers and Crickets.[1] — There are still other small creatures out of doors that will surprise us by their strong likeness to moths and butterflies. The grasshoppers and locusts, colored so like the ground or the grass that we do not see them till they jump or fly out from our feet, are a distinct feature of our summer. The chirpings of crickets and the songs of katydids bring us pictures of long pleasant summer evenings. If we look carefully at any one of these, what do we see? A small creature with a hard covering of chitin. It has a very prominent division into three parts — head, thorax, and abdomen. On the underside of the thorax are attached three pairs of jointed legs; on its upper surface are two pairs of wings. The abdomen is very evidently made up of rings or segments, and along the sides are small openings (spiracles) for breathing. The head has a pair of antennæ, a large pair of compound eyes, *and mouth-parts very much like the caterpillar's, evidently made for biting.* There must be the same close relationship of this group to the moths and butterflies.

However, there are a few strong differences that make the group a distinct one. *The first pair of wings are rather thick and horny and overlap the second pair, which are thin and membranous and folded like a fan.* In the greater part of the group the hind legs are very much stronger than the others, being adapted for jumping.

[1] Order *Orthoptera* (Or-thop'te-ra — *orthos*, straight; *pteron*, wing).

Perhaps the greatest difference lies in development. The little grasshopper just out of its egg is a grasshopper in appearance. We should never mistake it for anything else. It is like the adult grasshopper in every way except that it has no wings. It eats and grows, and moults its skin at intervals. Small inconspicuous wing pads on the back become larger after each moult. Finally, the grasshopper is full-grown and cannot be told from the grasshopper that laid the original egg. There has been no time in its life when it was helpless, and obliged to sleep for days or months, as is the case with the butterfly or moth. *There is no chrysalis or pupa stage. There is not a complete change of form from larva to adult; the larva looks like the adult, so the metamorphosis is said to be incomplete.*

The Group of Insects.[1] — If we compare all of these groups, — moths and butterflies, ants, bees and wasps, flies, beetles, grasshoppers and crickets, — we see that they are fundamentally very much alike. *In all, there exists a distinct right and left side, a covering of chitin, and a segmentation of the body. The body is divided into three parts. There is a single pair of antennæ, a pair of compound eyes, a mouth adapted for biting or sucking. There are three pairs of jointed legs attached to the thorax. There are one or two pairs of wings; there are spiracles and air tubes* (tracheæ) *for breathing. In all cases the development shows striking changes of form.* They are all bound together in close life relationship. They form the great group of Insects.

We have by no means exhausted the members of this group. We shall find the very same fundamental points

[1] Class *Hexapoda* (Hex-ap′o-da — *hex*, six; *pous*, foot).

of structure and development in May-flies and dragon-flies; in plant lice; in giant water-bugs; in cicadas, or "dog-day harvest-flies"; in the horned corydalis, or "dobson," used by fishermen for bait; in the caddice-flies with their wonderful instinct, while in the larval state, for constructing houses in which to live in the water; and in very many others.

This insect group is the largest group of animals in the world. There are not only the forms named but myriads of tiny creatures whose very existence is not known to the majority of us. They work out their simple lives generation after generation, have their successes, their thousands of tragedies, and we know nothing of it unless by some chance they interfere with our material comfort or success. There are more kinds of insects known than of all other animals taken together. In numbers they form the dominant group in the world.

Relationship of Insects to Spiders.[1] — The spider is another small animal that is exceedingly common. Is it an insect? Let us examine one carefully. The right side is just like the left, as is the case in all insects. It has the chitinous covering. The body shows, more or less distinctly, division into segments, and a separation of these into definite regions. There are jointed legs. In most of them there are spiracles and tracheae. They are very much like insects.

But we saw certain differences at a glance, and we can find others by studying a spider carefully. *There are four pairs of jointed legs. There are no antennae. The head and thorax are together as one piece, the cephalothorax* (ceph-a-lo-tho'rax). *There are no compound eyes,*

[1] Class *Arachnida* (A-rach'ni-da).

only simple eyes such as we saw in the caterpillar. There is a curious difference shown in connection with the breathing: numbers of tracheal plates are bound together, forming what are called lung sacs; each spider has one or two pairs of these sacs.

They certainly are not insects, though resembling them in certain fundamental points. They show a vital difference also in development; there are no mysterious changes of form, only increase in size; the little spider is the adult spider in miniature.

The spiders are rather high in development of their instinctive powers. They form an exceedingly interesting group for study. Some of us know the tubular ground nests of the turret spiders. Every one has heard of the trap-door spiders of California. We have all had our faces come in contact with the long tight ropes by which the "flying" spiders travel. These and many others have very curious habits.

The group to which the spiders belong includes the scorpions, the harvestmen or "daddy-long-legs," and other forms less common.

Relationship of Insects to the Crayfish.[1] — All through the Middle States and the south the crayfish (Fig. 214) is very well known. It lives in all the brooks and rivers and ponds, hiding under stones and shells, or digging out small caves for itself in the earth at the sides of streams. In New England the crayfish is not common; but there the lobster, its salt-water relative, is well known. Is this crayfish an insect? We may well ask the question, for it has a right side exactly like the left side, a thick chitinous covering, a segmented

[1] Class *Crustacea* (Crus-ta'ce-a).

body, a division of this body into head, thorax, and abdomen, and jointed legs.

But look at all the differences. *It has two pairs of antennæ. It has five conspicuous pairs of jointed legs. The head and thorax are united to form a cephalothorax. It has gills for use in breathing, instead of tracheæ.* The

FIG. 214.—Crayfish in alert position; showing relationship to insects by structure (bilateral symmetry, covering of chitin, segmented body, jointed legs, etc.). Natural size. Photographed from life.

crayfish is a representative of a nearly related but different class of animals, the Crustacea. It has as near relatives not only the lobsters, but also the different kinds of crabs and of shrimps. The well-known hermit crabs that live and fight their way under the protection of coiled mollusk shells; the giant king or horseshoe crabs that, when young, crawl in their burrows just under the surface of the sand of the beach at low tide; the fiddler crabs with their great fiddle-claws, sitting at the doors of their ground burrows; the rainbow-colored fairy shrimps gliding slowly and gracefully through the icy waters of

some March pool; all these and hundreds of others are members of the class Crustacea.

The Group of Arthropods.[1] — We found that the moths and butterflies were simply a subgroup of the insects. We now find that the insects themselves do not stand alone, but show very plainly by their structure that they are very nearly related to other forms. They in turn are simply a group forming a part of a still larger group, called the Arthropods. They and the group of which the spider is a type, and the group of which the crayfish is a type, are similar *in having right and left sides alike, in having an external coat of chitin, in division of the body into segments, and in having jointed legs.* Though not as nearly related to one another as are the groups of the insects to one another, they still agree in most conspicuous and fundamental characteristics. The group includes also the centipedes, or "thousand-legged worms."

Relationship of Arthropods to Worms. — Earthworms,[2] or "angleworms," are known throughout the country. Are they related to any or all of the forms we have considered? *They have right and left sides alike, an external coat of chitin, and a body made up of rings or segments.* They must be related, but very much more distantly than any of the other animals mentioned. They lack one great characteristic which would ally them very closely with the others, namely, the jointed appendages. No true worm has jointed legs. So, strictly speaking, we are not right in calling caterpillars worms, for they have three pairs of jointed legs. We must remember that they are not worms any more than the crayfish is a fish.

[1] Branch *Arthropoda* (Ar-throp'o-da).
[2] Representatives of the branch *Annelida*.

SYNOPSIS OF A PART OF THE INVERTEBRATE ANIMAL WORLD ARRANGED IN DESCENDING SERIES TO SHOW NEAR RELATIVES OF MOTHS AND BUTTERFLIES[1]

Moths and Butterflies . . . .

Bilateral; covered with chitin; segmented; with jointed legs; division into head, thorax, and abdomen; breathing by spiracles and tracheæ; two pairs of wings on thorax; mouth-parts in larva fitted for cutting; wings covered with scales; mouth-parts in adult fitted for sucking. Metamorphosis complete. Instinctive powers of high order.

Ants, Bees and Wasps . . . .
Flies and Mosquitoes . . . .
Beetles . . . . — INSECTS.
Bugs, Aphides, etc.[2] . . . .
Other smaller groups . . . .

Grasshoppers and Crickets . . . .

Bilateral; covered with chitin; segmented; with jointed legs; division into head, thorax, and abdomen; breathing by spiracles and tracheæ; two pairs of wings on thorax; mouth-parts fitted for cutting. Metamorphosis incomplete. Instinctive powers of inferior order.

— ARTHROPODS

CENTIPEDES.
SPIDERS . .

Crustacea . . . .

Bilateral; covered with chitin; segmented; with jointed legs; separation of anterior segments in cephalothorax; breathing by gills. Gradual development by moults from larva to adult.

Worms.

Bilateral; covered with chitin; segmented; never with jointed legs.

[1] The arrangement of the first four groups of insects is not intended to indicate that the one containing the moths and butterflies is the highest. These groups are specialized along such different lines, it is impossible to say which is highest.
[2] Order *Hemiptera* (He-mip te-ra).

The Ancestry of Moths and Butterflies. — As we pass in consideration from moths and butterflies on to grasshoppers, to the crayfish, and finally to worms, we find creatures more and more simple, with fewer special adaptations for their lives, yet showing much the same fundamental structure. This common plan on which they are built means close relationship. It is generally believed that insects had a common worm-like ancestor and that they have developed along different lines, becoming fitted for different environments or adapting themselves to new or changing conditions of climate, etc., through centuries and ages, until there are the distinct groups to-day, all still having the primitive structure as their fundamental feature.

A caterpillar or larva of a moth or butterfly is worm-like; we are not surprised that it is commonly called a worm. But it has jointed legs, as have the Crustacea, and a distinct head with mouth-parts for biting, like those of the grasshopper. Later it becomes very highly specialized. This also seems to prove that it has developed from a worm-like form, has become more complex, resembling the type represented by the lower insects, and has finally developed into a group with special adaptations for a different kind of life; for it is believed that animals repeat in a general way in their development the history of the development of the race to which they belong.

The history of its growth from the egg is a proof of relationship to these lower forms. Crustaceans have larval forms that become the adults by gradual changes taking place at periodic moults. Grasshoppers and many of the insects have much the same sort of development, the animal remaining active throughout. But

among the moths and butterflies the larva eats greedily, storing up so much food in its body that after a few moults it can go through the others without taking more nourishment, and so it passes into a resting or quiescent stage (the chrysalis), in which the adult structures are perfected. On each chrysalis there is a pair of peculiar crescent-shaped spots over the eyes of the sleeping insect. These crescents are very plainly seen on most chrysalides. It is said that these are remnants of eyes and help to prove that at some time in the history of the development of the race the chrysalides led active lives, as do the larvae of grasshoppers and others.

General Relationship of Moths and Butterflies to Other Races. — Moths and butterflies feed upon the nectar of flowers. Flowers and butterflies are always connected in our minds, not only by their close association in gardens and along roadsides, but by their similar gay coloring. We know well the

> ". . . painted populace
> That live in fields and lead ambrosial lives."

The race of flowering plants is of great value to the race of moths and butterflies; the leaves supply food for the larvae; the flowers give honey to the adults. Is the race of moths and butterflies of any value to flowering plants? The answer is hinted at in Hood's line, "These be the pretty genii of the flowers." In many cases flowers are in absolute need of these genii to bring the pollen from other flowers of the same kind in order to make seeds. Butterflies and moths are their unconscious agents who never fail in the work, since they are paid with necessary food. This is one of the many

instances existing in the world in which two races are related for their mutual good.

This relation shows that moths and butterflies are of great service to us, since we are dependent on flowering plants for food.

However, caterpillars, the larvæ of moths and butterflies, feed upon the leaves of these same flowering plants. Are they our enemies? When they are in large numbers, yes; but in the majority of cases caterpillars are in just such numbers that they do necessary pruning work, forcing plants to a more vigorous growth. When plants grow from the seed in a wild state, they are likely to be so close together that none of them has a chance to grow. By eating some of these plants, caterpillars decrease the struggle for existence for the others, giving them more space, more food, and more light, and so a better chance for thrifty growth.

Usually there is a balance of life in the world in which every race is held in check by its enemies and by a limited and scattered food supply. But under high civilization in a country where many kinds of plants are massed over large areas, as in our fields of cotton, corn, grains of all sorts, cabbage, etc., in our orchards of apple and peach, and in vineyards, we must expect great increase of any kind of moth or butterfly that can feed on these, since, to repeat, any increase of a race is dependent on food supply and on distances necessary to be traveled in the face of enemies to get this food. Besides, in a highly civilized country, there will be many ways of rapid transportation of agricultural products, thus furnishing means by which insects can spread from one part of a country to all other parts or even from one country to another. Thus the balance

of life that usually exists in nature is destroyed under the conditions of high civilization, and man must give active attention to the agricultural interests of the country.[1]

The best protection can be given when a knowledge of the habits and life histories of the insects forming the pest are known by the farmer or gardener. Then they can be avoided by a somewhat earlier or a later planting or harvesting; perhaps by immediate destruction of the waste parts of the crop after the harvest; or sometimes by fall ploughing, so as to turn up to the surface the larvae or chrysalides hibernating in the ground for the winter.

Many kinds of insect pests can be destroyed by spraying the plants with Paris-green water or with some other poison at just the right time in the spring. This spraying should be a recognized part of the farm work, just as much as weeding is. If we provide rich soil full of food for plants, we expect a large growth of weeds; if we raise luxuriant crops over large areas (large food supplies for insects), we may expect pests. One needs as much attention as the other.

One of the most effective methods of keeping crops free from insect pests is by crop rotation — by changing the crops on given areas of land in succeeding years. This will usually result in starving out any given variety of insect. Another effective method consists in introducing into the locality infested some parasite or other enemy of the pest.

[1] Refer to the various bulletins issued by the Departments of Agriculture and Entomology at Washington, D.C. Read Weed's "Insects and Insecticides," published by the Orange Judd Company.

However, most of these precautions concern insect pests other than moths and butterflies; they, as a group, containing fewer offenders than other groups. To be sure, the Cankerworm, the Codlin moth, the Army-worm, the Gypsy moth, the Tomato-worm, the Cabbage butterfly, the Cutworms, and some others are well-known and troublesome pests; but the destructive work done by them does not compare with that done by the chinch-bug. the Hessian-fly, by locusts and wire-worms, by all the borers, all the hundreds of kinds of fruit and leaf scales, by the saw-fly larvæ, and by the thousands of known and unknown beetles, bugs, and aphides that infest cultivated plants. The farmer's problem becomes a very large one when we consider the number of insect pests he must guard against.

Very often caterpillar pests can be traced directly to man's interference in the balance of nature. One instance is seen in the Gypsy moth introduced into Massachusetts, and another perhaps in the Cankerworm pests, the result of the decrease of insect-eating birds relative to the increase of the seed-eating English sparrow introduced into this country from Germany and England.

We have seen that under natural conditions moths and butterflies are of value to man because of their relation to flowering plants. A large part of their economic value lies in the silk-spinning habit of a part of the group. This value is likely to increase rather than decrease, since silk is so valuable a textile product, and since America has so many native silk-spinning caterpillars of large size.

There ought to be great reverence for the life of the moth or butterfly in all its stages on the part of every

thinking individual, since under natural conditions that life, which is a part of the great life of the universe, fills a position of immeasurable value to birds, to plants, and to man, interrelated with these races for mutual good. It is only when the balance of life is destroyed in one way or another and this race interferes with the success of some other race that the moths and butterflies should be sacrificed.

> "He who feels contempt
> For any living thing hath faculties
> Which he has never used; thought with him
> Is in its infancy."

HOW TO COLLECT, KEEP, AND STUDY BUTTERFLIES AND MOTHS

HOW TO COLLECT, KEEP, AND STUDY BUTTERFLIES AND MOTHS

On collecting Caterpillars. — If we are to study nature[1] in any form, the question of material is an important one; the question of *live material* is the vital one — live material in its *native environment*.

Then for this work let us go caterpillar-hunting on any day from the first of June till the last of September. Take small pasteboard or tin boxes, for we shall wish to bring home some of the caterpillars to watch their development. Or take a botany collecting tin or a covered tin pail in which to carry them and in which to keep quantities of their food plants fresh. The hunting is likely to be more successful if the day is a dull one or if it is a morning after a night of rain. We can see the caterpillars better if the sun is not too bright in our eyes; also on dull days many caterpillars stay on their food plants instead of crawling down the stems and hiding on or near the ground, as is their usual custom; and a stormy night may prevent their eating their usual supply, so that they remain on the higher leaves of the food plant during the morning.

Caterpillar-hunting has many charms, as you will admit after your first or second trip; as in all hunting, the joys increase with experience. Like other hunting, it requires

[1] "Study nature, not books," Agassiz's motto, must be the keynote of nature study. We must get our facts from nature, and interpret these facts according to our best judgment; then use books for reference.

the keenest eye and a mind that can reason. The best hunting grounds are the sides of country roads, the edges of woods, half-cleared fields, and gardens. Low, fresh second growths of oak, poplar, or elm will pay investigation and may give us many kinds of caterpillars. A low growth of wild cherry is almost sure to yield a harvest, and as we approach it we are eager for the prizes it may have concealed. Scan the brown bark closely for a brown, curiously humped caterpillar of the Red-spotted Purple butterfly (Fig. 84). Look on the undersides of leaves, at the ends of branches, for colonies of brown spiny los arranged closely side by side (Fig. 128). Look on the undersides of leaves anywhere on the tree for blue Prometheas (Fig. 102), or for Cecropias in their black, orange, or green livery (Figs. 100, 138, and 139), and do not be startled if two great eyes seem to try to stare you out of countenance: it is only the caterpillar of the Tiger Swallowtail butterfly—green in color. It rests on its silken bed on the upper surface of a leaf; its two great eye-like spots on the swollen head end make it seem rather formidable (Fig. 57). We may find all these and more, but we must not be surprised if the wild cherry is quite bare of its caterpillar guests. If so, let us go on with increased eagerness to the next low growth.

Tangles of Virginia creeper and wild grape always hold out hopes of giant Sphinxes (Fig. 202), which can often be found by discovery of the excrement on the leaves below them. Sassafras entertains several kinds of caterpillar friends, feeding them on its delicious leaves. Among these we may find, in September, Prometheas and the great-eyed "bugaboo" larvæ of the Green-clouded Swallowtail (Fig. 58). Apple, as we know, is a great favorite

among caterpillars, from the giant Cecropias and others, that never are in large enough numbers to do any damage to the trees, to the Cankerworm measuring the distance it travels inch by inch and doing inestimable damage.

After we have gained enough acquaintance with caterpillars to be interested in them, and our interest has become great enough — as it is sure to do — to overcome the repugnance we may have felt for all members of the caterpillar world, out-of-door life will have an added charm, and in our country walks many plants will have added attractiveness, because we possess one or more secrets in regard to the guests they entertain. Even the birch will be more beautiful than before, because we know it may hold concealed somewhere on the edges of its green leaves the translucent green larva of the beautiful Luna moth (Fig. 163).

We may find several kinds of caterpillars feeding on bayberry in September. A hop vine will almost always give us the caterpillars of the Interrogation butterfly (Fig. 78) and of the Comma. As we walk through the fields or along the road, close scrutiny of the milkweeds will bring to light the larvæ of the Monarch (Fig. 7). Here is a clump of nettle. Look sharply for the folded leaves which form the houses of the caterpillars of the Red Admiral (Fig. 75). A cluster of everlasting may mean a Painted Beauty (Fig. 71). A field of wild carrot has its accompanying dozens of caterpillars of the Black Swallowtail (Fig. 29). We can find a great many kinds of caterpillars in the garden. There are discoveries and discoveries ahead of us just for the looking.

When we find leaves eaten so that only the midribs are left, or partially eaten, with edges cut into irregular

curves, we may surmise the presence of large caterpillars. If small holes are eaten through the leaves we may find young caterpillars, but more likely the work was done by beetles or leaf-cutter bees. Caterpillars very often make nests for themselves by folding leaves or by fastening several leaves together. This is a clue to finding them.

We are likely to find many caterpillar-like creatures which will never change into moths or butterflies, no matter how long we keep them. These are saw-fly larvæ and are very common. They are usually social in habit, often feeding at the edges of leaves; they can be distinguished from caterpillars by the fact that they always have more than five pairs of prolegs. The common currant-worm is a familiar example.

Out-of-door Study of Caterpillars. — It takes sharp eyes to find caterpillars. After we have found them let us notice the following points:

Where are they when found?

Can you tell what their food plant is?

What are they doing when found?

Are they social or solitary?

Are they protected where they are by their color, form, or markings?

How are they affected when we lightly touch either their food plant or themselves?

Would what they do when disturbed protect them from an enemy — an ichneumon fly, a bird, a lizard, a toad, a spider, etc.?

When we have found out all we can in the few minutes we are able to watch them out of doors, let us take some of them home to trace their development and find out

who they really are. With them we must take some of the plant on which we find them feeding, for as a rule caterpillars are extremely particular about what they eat, and if we do not give them their chosen plant they will die.

How to keep Caterpillars in Captivity.—It is a comparatively easy matter to keep caterpillars in captivity

FIG. 215.—Wooden frame covered with wire netting; glass door in front. Wet sand in bottom, in which can be placed food plant.

until they have passed through all their transformations and we have found out all their secrets. Two things are absolutely essential to their healthy living—*clean houses* to live in and a constant supply of *fresh food*. Any method for keeping them, giving these essentials, will be

a good method. Cages, consisting of wooden frames covered with wire netting, set on boxes of damp sand, will give good results (Fig. 215). Branches of the food plant can be supported and kept fresh in the wet sand, and the caterpillars will be quite at home. Large lamp chimneys or lantern globes set on flower-pots of earth or sand, and closed with a piece of plain glass at the top, or a tied-down cover of mosquito netting, will also serve well. A small plant on which the caterpillars feed can be transplanted to the flower-pot. The glass must be kept clean, so that they can be seen plainly. Pasteboard boxes

FIG. 216. — A shallow dish of clear glass, with glass cover, convenient for keeping caterpillars. Forceps convenient for handling them. The law that will bring success in raising caterpillars is "clean houses and fresh food."

will serve, but are poor, because we cannot see through them, and because the food plant will keep fresh but a very short time, and so must be renewed every few hours.

Good results can be obtained by keeping caterpillars in almost air-tight houses; in which case the food plant keeps fresh and the caterpillars seem to suffer no inconvenience because of lack of air, provided the law of cleanliness is followed. Shallow tin boxes (wafer boxes or bread tins) with windowpanes for covers, or, better still, shallow plain glass dishes with clear glass covers, make admirable caterpillar houses (Fig. 216).

Once or twice each day the houses must be uncovered and turned upside down on a paper. The empty dishes can be rinsed, dried, and filled with fresh food plant. Then the caterpillars can be moved from the paper to their houses and all is right.

In moving caterpillars from one place to another, and in examining them, a pair of slender forceps of delicate spring is almost indispensable. In no case is direct sunlight to touch boxes or glasses (Fig. 217) in which caterpillars are kept.

FIG. 217. — Any convenient plain glass dish will serve as a caterpillar house.

Indoor Study of Caterpillars. — As we feed and care for the caterpillars, there are many structural and other points that we can find out about them.

Describe the color of the caterpillars.

Is their color of value to them?

Are they protected by their shape, or by the attitude taken, or the situation chosen, when resting?

Have they other means of protection — osmateria, spines or hairs, combative attitudes, etc.?

Compare the two sides of the caterpillar.

How many segments in their bodies?

What is the value of the great flexibility of their bodies?

How many jointed legs have they? Tell their position and use.

Tell the number, position, and use of the prolegs.

Describe method of walking. Illustrate with diagrams.

What is the size and position of the mandibles?

Show by means of a series of diagrams the order in which a leaf is eaten.

What is their favorite food plant?

Will they eat the leaves of other plants? (Give them many kinds to see which is chosen.)

Locate the spiracles.[1]

How rapid is the growth of the caterpillar? (Make measurements at intervals of several days.)

Observe the process of moulting and discover why the carpet of silk is spun before the moult.

How many moults take place before the caterpillar is full-grown?

Do the moults occur at regular intervals?

What is the attitude of one caterpillar toward others of the same kind?

Do the caterpillars of a kind show any variation in coloring?

Make a diagrammatic drawing of the caterpillar to show structure (Fig. 9).

Observation of the Change to Chrysalis. — As soon as the caterpillars are full-grown they stop eating and become very restless. They are ready for the change to the chrysalis form. Usually there is some decided change of color to tell us that it is about time for this final moult.

Turnus changes from green to dull brown at this time; Troilus to bright yellow; Cecropia from light blue-green

[1] A magnifying glass of some sort is of great value in studying moths and butterflies.

to dull yellow-green; Sphinxes are apt to become dull purplish brown; etc. At least the colors will be dulled even if there is no marked change. In all cases the digestive tract is thoroughly emptied, ready for the long sleep that is to follow. This and the general behavior of the caterpillar might make us conclude that

FIG. 218. — Twigs utilized by Chinese Silkworms as supports for cocoons. Photographed from life. (Refer to Fig. 167.)

it is sick and that we are not to see the moth or butterfly after all. But here, as in all cases in this work, we must withhold judgment and watch.

If the caterpillars about to perform the change to chrysalis are those of the butterflies, they must be given twigs on which to fasten their naked chrysalides (Figs. 73, 81, and 86). Or if they are in glass houses covered with glass, a piece of thick paper or pasteboard can be slipped under the glass cover. The caterpillars can be watched

through the sides of the glass dish. They will fasten their chrysalides to this paper, and so are in a convenient position for further study.

Many moth caterpillars spin cocoons. They must have slender branches to which to fasten the cocoons (Fig. 218). Other moth caterpillars (among which are the Sphinxes) go into the ground for this change (Fig 193). These must be put into a wooden box or flower-pot of earth and given the chance to burrow. Unless we are familiar with the habit of the caterpillar, it is always best to make the conditions such that it can either spin a cocoon or follow its instinct for burrowing.

Here are interesting situations, indeed! And many secrets to find out!

Observe a caterpillar spin its cocoon.

What supports are used for the cocoon?

Where do the threads of silk come from?

What part is built first?

Describe the movements of the caterpillar's head as it spins.

How long before the cocoon is finished so that sounds of spinning can no longer be heard?

Watch a caterpillar go into the ground.

With what part of the body is the burrow made?

How deep is the burrow?

By what process does a caterpillar make its house roomy below ground?

Let a caterpillar burrow into sand or earth in a tall tumbler or glass preserve jar.[1] Place the glass in a

[1] The glass should be cleaned and thoroughly dried, then filled with earth or sand of the moisture of ordinary garden soil.

dark room or wrap it in thick paper to darken it. The caterpillar will burrow as far down as it can, and will be likely to hollow out its cell somewhere against the glass, and so will be in plain view when the paper is removed.

Perhaps the most interest lies in watching a butterfly caterpillar during the change.

What position is taken by the caterpillar in preparation for the change?

By what process does a caterpillar get a girdle of silk about itself?

There is nothing mysterious about it. Sharp eyes can very easily see how it is done and what ingenuity the caterpillar seems to display. Then the skin is shed in plain view.

Where does the skin split?

How does the chrysalis get out of it?

How does the chrysalis withdraw its end from the caterpillar skin and fasten this end in the silk above without falling?

What is the condition of the chrysalis just after the moult and one-half hour later?

What is the size of the chrysalis compared to that of the caterpillar before the change?

Indoor Study of Chrysalides. — *Is there any proof that the chrysalis is alive?*

Identify the lower or front side of the sleeping butterfly or moth (in the butterfly chrysalis it is likely to be the smooth side), with the proboscis, legs, and antennæ lying close together on the surface.

Describe the position of the wings.

Are the hind wings visible?

How many segments can be identified (count on the back of the chrysalis)?

How many pairs of spiracles are visible? (One pair is on the first segment, at the head end of the chrysalis.)

How is the chrysalis protected?

How long does the chrysalis stage last?

Draw the chrysalis in side view, naming parts.

Indoor Study of Cocoons. — *Describe the outside of the cocoon.*

Is it made of anything besides silk, such as leaves, hairs of the caterpillar, etc.?

Cut open a cocoon. Use finely pointed scissors, holding them in a position very oblique to the surface, and letting only the points enter, so as not to injure the chrysalis within.

Compare the size of the chrysalis with the space in the cocoon.

Is the chrysalis fastened in the cocoon?

What is the shriveled mass that is also within the cocoon, and is its position with reference to the chrysalis the position you would expect?

Describe the inside of the cocoon.

If the cocoon is double, with a space between the two parts, why is it a better protection than it would be if single, with the same amount of silk?

Is the cocoon open to the exterior?

If so, what is the relation in position of the chrysalis to this opening?

Is the cocoon more easily opened from within or from without?

Soak the cocoon in hot water and see if the silk can be unwound and measured.

On collecting Cocoons and Chrysalides. — We can learn very much indeed from the indoor study of cocoons and chrysalides and their formation. But we do not know all until we try to collect them out of doors and find out by sorry experience how very hard they are to find and how exceedingly well they are protected from enemies by their color, their shape, and their location.

The chrysalides formed underground usually remain there during the winter, but in the spring, by vigorous movements of the abdominal segments, they work their way to the surface and rest there, perhaps protected by a covering of fallen leaves and twigs. We may be very successful in finding them by slowly turning over the leaves on the ground under elms, oaks, poplars, willows, walnuts, butternuts, and many other trees. (A forked stick makes a very good rake.)

Some cocoons are made fastened to branches of the food plant and so are found with considerable ease after a little experience. These caterpillars sometimes spin high on the tree, but just as often they descend so that the cocoons are made from one to two feet from the ground. We are reasonably certain of finding Cecropias on alder, apple, wild cherry, and willow, although we may find them on any one of thirty or forty other plants. We are almost sure to find Prometheas swinging from the sassafras, wild cherry, ash, buttonwood, and spice bush after the leaves have fallen from the trees in the autumn.

The Polyphemus, Luna, and others are made among the leaves on the tree, but fall to the ground with these leaves. We must look for these cocoons on the ground under the food trees.

We can get a rich harvest of cocoons of many kinds by looking in all sorts of protected places — under the edges of sidewalks, on the undersides of stones, on fences and houses and outbuildings, in protected corners among piled wood and stone, on the rafters of barns and sheds, under bridges, under the loosened bark of trees, etc.

Butterfly chrysalides! You will feel a sense of great satisfaction if you find them — the satisfaction that comes from having done a thing that is extremely hard to do. Antiopas may often be found on fences and foundations of houses near elms and willows in June and again in September. Asterias chrysalides have often a similar location, but in this case they are near fields of wild carrot or parsnip, remaining in this position all winter. The gold or silver "Hop Merchants" of the Interrogation or Comma butterflies may usually be found on hop vines. After we have found these our eyes ought to be sharpened so that we can find others. Try it. Look for the green and gold chrysalis of the Monarch in June and again in September. Look on or near sassafras for that of the Green-clouded Swallowtail. Find, if you can, the chrysalides of the Cabbage butterfly, or those of the yellow Clouded Sulphur that in the caterpillar stage feeds on clover. These small forms, colored like their surroundings and hanging motionless, are most wonderfully protected, as it is imperative they should be, while they are bound in this helpless condition.

Out-of-door Study of Chrysalides and Cocoons. — *What is the situation of the chrysalis (butterfly)?*

Is it protected from rain and from direct sunlight in this situation?

In what way is the chrysalis fastened to its support?

If the chrysalis has points or projections on it, of what value are they to the sleeping butterfly within (butterfly parts do not extend into these projections)?

What is the out-of-door situation of the cocoon?

Is its shape or color of value to the sleeping moth inside in this situation?

What hinders birds from tearing open cocoons to eat the chrysalides?

How to keep Cocoons and Chrysalides over Winter. — Cocoons and chrysalides that are made by caterpillars in captivity, and those that we gather in field work, must be kept alive over the long winter season. This is the difficult thing to do. Three things must be avoided: frequent and great changes of temperature, great dampness which might result in mould, and great dryness. Any one of these will prove effectual in killing the chrysalides. Any method of keeping them that will avoid these will prove a good one.

The air of an ordinary living room is too dry. This may be counteracted by moistening the chrysalides and cocoons frequently, or by keeping them on a small wire-net table, set low over a pan of moss kept thoroughly wet. However, under these conditions the moths and butterflies will develop too rapidly and will reach the adult state very early in the spring, in February and March, before the leaf buds of the trees are opened or flowers are out to furnish food for them. Cocoons and chrysalides wrapped in cotton or thin papers can be kept in boxes or fruit jars, in a cellar, unheated room, or closet, or in a sheltered shaded place out of doors. There

is nothing to be feared from continued low temperature. In fact, about the most successful way is to pack them loosely between folds of cotton in a wooden box and keep them in an ordinary refrigerator until April or May. Cold storage is the best method for keeping hibernating

FIG. 219. — Home-made cocoonery, open at top.

caterpillars. If the boxes or fruit jars are kept in the cellar or a closet, they should have covers of wire netting to keep out mice.

The last of April or the first of May they should be brought into light and warmth so that further development can go on. Put them into the wire-net cage (Fig. 219) on a layer of slightly moistened sand. Put over them, if you wish, a few brown leaves and twigs to imitate the condition that would exist if they were out of doors. In the sand stand up branches as tall as

the cage will allow, so that the moth or butterfly will have something to climb upon, and a final support when it comes out heavy and wet-winged. Instead of a wire cage, a large rectangular or cylindrical aquarium[1] can

FIG. 220. — Aquarium cocoonery.

be used to good advantage. Moist earth or sand in the bottom will give a foundation for growing moss and ferns. A large-sized window glass or a rectangle of wire netting will serve as a cover. This makes an ideal

[1] These aquaria can be obtained from either Whitall Tatum Company, of New York and Boston, or from Bausch & Lomb Optical Company, of Rochester, N.Y. So can large battery jars, which are cheaper and serve well; also shallow clear glass dishes (so-called crystallization dishes), which are ideal for caterpillar houses. Covers cut from ordinary glass can be obtained at any hardware store.

house for developing moths and butterflies (Fig. 220). We can see them as clearly as though they were not confined at all.

Observation of the Change to Butterfly or Moth. We must see the moth or butterfly leave its cocoon or its chrysalis skin. If we watch a chrysalis, we can tell when the change is near. It becomes soft to the touch and very often undergoes a complete change of color. Usually for twenty-four hours before the butterfly emerges, we can see its color and markings through the thin transparent chrysalis skin from which the creature within is separated.

Where does the chrysalis skin open?

Which parts of the butterfly are free first?

How long from the first click of the chrysalis as it splits open to the time when the butterfly is entirely free?

What is the position taken by the wet butterfly for its further development?

Watch the expansion of its wings as the blood is pumped into them from the body.

How long before the butterfly gets its full strength?

Watch the butterfly's management of its proboscis during the first ten minutes after it leaves the chrysalis.

It is difficult to tell when a moth is to come from its cocoon. Usually a moth chrysalis is rather active for several days before the final change, so that the cocoon will dance; but it may be perfectly quiet unless disturbed. As a rule, moths emerge during the morning between nine and eleven, but there are many exceptions.

How does a moth escape from a cocoon securely closed everywhere?

Which part is free first?

Watch the wings as they expand, revealing their color and pattern.

Compare the size of these wings when the moth first escapes from its cocoon with their later size.

Compare the size of the abdomen as it is at first and later.

Note the spiracles on the sides of the abdominal segments of the wet moth ; they will not show plainly later.

We have now seen the last transformation, and we have found out who our caterpillars are.

Indoor Study of a Moth or Butterfly. — *Compare the right and left sides of the moth or butterfly.*

Note the rings of the body.

How many pairs of legs do you find?

Are the legs jointed?

The butterfly or moth is covered with chitin.

It has spiracles and tracheæ for breathing. (*These spiracles are concealed by the hairy covering of the body.*)

Identify head, thorax, and abdomen.

Identify and describe the organs of the head:

1. Compound eyes — size, color, position, use.

2. Antennæ — shape, structure, use.

3. Proboscis — length, use, position, and protection when not in use.

What is the position of the jointed legs?

How are they adapted for clinging?

Tell the number, position, and use of the wings.

Describe their color and shapes.

Compare the coloring and shape of the hind wings with those of the fore wings.

Draw the moth or butterfly in some natural position, preferably with spread wings and in back view, to show

the head with antennæ and eyes, the thorax with wings, and the segmented abdomen. Take care to make the wings of one side exactly like those of the other in shape and color-pattern. Put in no line unless it means something.

In what two ways are the wings strengthened?

Draw the wings of one side to show the arrangement of veins.

If it is possible to obtain a strong hand lens or a microscope with which to examine a wing of the butterfly or moth, draw a fragment of the wing surface to show the shape and arrangement of the scales. Make the drawing just as truthful as you can.

Compare a butterfly or moth with a caterpillar.

Compare a butterfly and a moth. (Give likenesses; then differences.)

Compare butterflies of a kind. Is there any variation?

Field Work on Butterflies. — We must know the moths and butterflies not only through indoor study; we must know them also in the lives they lead in their chosen out-of-door homes. So again we must go afield, and what we see let us try to interpret from the butterfly's standpoint. June and September are the best butterfly months; but various kinds of butterflies may be found at any time from March until November. In studying them out of doors try to answer some of the following questions:

How early and how late in the summer season can you find this kind of butterfly?

During what part of the day does it fly?

In what kinds of weather does it fly?

By its numbers at different times during the summer, can you tell how many broods it has?

Describe its flight.

What enemies has it?

How is it protected? (By high flight; irregular flight; color and shape on flowers, leaves, tree trunks, branches, etc.; by playing dead when caught, etc.)

In what sorts of places does it live?

What flowers serve it for food?

Does it eat anything besides the nectar of flowers?

What is its position while eating?

Watch the use of the proboscis and antennæ while it is eating.

On what plant or plants does it deposit eggs?

Is the butterfly social or solitary in its habit?

What is its resting position?

Are all the butterflies of a kind exactly alike in size and color?

We shall find many butterflies in low meadows with clumps of bushes and low growths of various kinds; many more on hillsides and upland fields, especially if there are growths of thistle, milkweed, and nettle at hand. Often butterflies will assemble around muddy pools in the road or at some place on the muddy edge of a pond or river. An orchard or cider mill in the fall is one of the best places for studying butterflies. There can scarcely be a better place than a large old-fashioned garden, with its tangled masses of flowers.

How to collect Butterflies. To catch the butterflies we must have a net. Butterfly nets can be bought for a dollar, or less, from a taxidermist or from any dealer in entomological supplies, or they can be obtained by sending to the Kny-Sheerer Company, New York. This firm sells also a very convenient net with folding rim (Fig. 221).

However, a good, strong net can be made at home. The cloth may be put on a strong frame made by a blacksmith. This frame may consist of a ring one and one-fourth feet in diameter, made of strong telegraph wire and fitted firmly to a light wood handle three feet long. The net should be made of fine tarlatan or mosquito netting. It should be sewed firmly to the ring after the ring has been covered with strong cloth to prevent wear. The net should be longer than broad, so that by a twist of the handle the butterfly can be made prisoner in its end, and this end should be rounded, so as to have no corners in which the butterfly can get caught. This net will be rather heavy, but will serve admirably for catching butterflies after they have alighted. To catch butterflies while they are flying, a short-handled, larger, lighter net is needed. The net Denton describes is best — an eighteen-inch rim of rattan on a one and a half or two-foot pine handle (Fig. 222).

FIG. 221. — Convenient net with folding rim sold by the Kny-Sheerer Company, New York.

A little experience in trying to catch butterflies will give the needed skill. It requires cautious approach and extremely rapid movement. After having several long, hot

chases after flying butterflies one will come to the conclusion that the easier and surer way is to go slowly and wait for the butterfly to alight or to come near, when a few quick steps and a rapid sweep of the net will make the capture.

A cautious approach will very often allow one to take the rarest butterfly from the flower on which it is feeding.

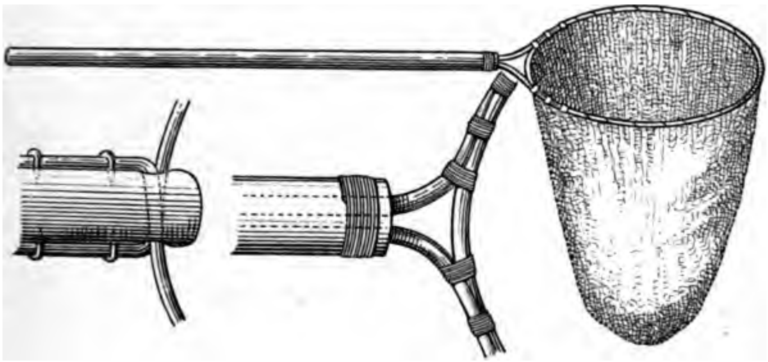


FIG. 222. — An 18-inch rattan rim on a 1½-foot pine handle. After Denton.

Painted cards are often used as decoys, and decaying fruit or a sweet syrup of some sort is often put out as a bait to attract them.

If we are to take them home alive, it will be best to put them as soon as captured into a tin pail, a botany collecting tin, or some box that will be totally dark when closed, so that it will produce night for the butterflies. In a dark cool place they will sleep instead of beating their wings in an effort to escape. In transferring them from the net to the box great care must be taken not to rub any of the scales from the wings. Let us take some of their favorite flowers, also, so that they can be made comfortable during the time that we wish to watch them at home before we release them again. If we have no flowers, they may eat syrup or fruit.

On collecting Moths. Since the moths are night-flying, the easiest way to get acquainted with most of them is to raise them from the caterpillars, which are easily found.

However, the Sphinxes are dusk-fliers and can be caught near honeysuckles, phlox, syringa, lilac, and other garden flowers at night, just before it is dark. These Sphinxes, besides having powerful wings, are provided with spines on the legs, so that it is much more agreeable to capture them with a net than with the hand.

Many moths, large and small, can be attracted by a strong light set in an upper window of a country house, especially on a warm night when there is no moon. Many large moths can be caught about electric lights in villages, and even in cities, on summer nights. The large Royal moths and the Sphinxes are among the number attracted to these powerful lights.

The willow catkins on a warm night in spring attract many kinds of moths. In a locality where there are few flowers many moths can be captured by the process of sugaring. That is, a thick syrup of some sort is spread on tree trunks or fences before dark and the place visited later with a light and a net.

The method of assembling is largely used by entomologists who wish a large number of any one kind of moth, especially of the large Giant Silkworms, Luna, Polyphemus, Promethea, etc. A female of the kind desired is exposed out of doors in a net of some sort. The male moths will flock about the net and can easily be made prisoners. This is a method by which many perfect specimens of a kind can be obtained for the study of variation.

After considerable experience in collecting we can find many moths in the daytime in their resting positions.

Polyphemus, Cecropia, Io, the various varieties of Smerinthus (Frontispiece), and others hanging from the branches or the leaves of their food plant will look like brown leaves, but the interested eye can tell the difference. Many of the large owlets and the Sphinxes can be found in shaded positions on stones or fences, on outbuildings and house foundations. Many varieties of the Underwings can be found under bridges or on the trunks of forest trees.

On collecting and studying the Eggs of Moths and Butterflies. — Large numbers of moth eggs can be obtained from moths kept in captivity, since they usually lay the eggs in large clusters and very soon after quitting the chrysalis state. Butterflies, as a rule, lay their eggs singly and at comparatively long intervals, so that it is much more difficult to obtain eggs from butterflies in captivity. The eggs will sometimes be deposited if we expose butterflies in a large net house with fresh leaves of the food plant, on which they are known to place their eggs.

However, moth and butterfly eggs, although so minute, can be found rather easily out of doors. We may be able to see a butterfly in the act of depositing eggs. Before we have had the experience of finding these tiny iridescent gems on the undersides of the leaves of the various food plants, we cannot realize the delight of the discoveries that can be made while taking a country walk in summer.

All moth and butterfly eggs are usually very beautiful, because of their symmetry and the iridescent quality of the chitin covering them. Usually butterfly eggs are decorated with a pattern of some kind, while those of moths present a plain surface. The relationship of moths

and butterflies is shown by the eggs, as well as by other stages of development, and although there are many exceptions to this likeness, one soon learns to recognize the eggs of a Sphinx, of a Giant Silkworm, of a Four-footed butterfly, etc.

If we have the egg stage for study, it will be of interest to note the following points:

What is the situation of the egg on the food plant?
Describe size, shape, and color of the egg.
What enemies has it?
How is it protected?
How long does the egg state last?
Are there changes of color during its development?
Can the young caterpillar be seen through the egg-shell before the egg hatches?
What is the caterpillar's method of escape?
Where is the opening in the egg made?
Does the caterpillar devour the remains of the egg-shell after its escape? If so, what is the value of the action to the young caterpillar?

Permanent Collections of Moths and Butterflies.— As a rule it is best that the collecting instinct, which we all possess, should work itself out on coins, stamps, and other inanimate objects rather than on moths and butterflies, where so many lives must be sacrificed. This is true especially because the collecting in the majority of cases is limited naturally to the largest and most beautiful members of the group, which happen to be the most beneficial also. There is the possibility that these moths and butterflies will be killed out entirely.

However, a carefully prepared collection may be of great service in identifying and classifying the moths and butterflies of a given locality. A collection may be a very good thing, especially if made by a school or by some community of people, all contributing toward it, or if it be made by a person interested not only in getting as many specimens as possible, but also in the lives and relationships of the moths and butterflies themselves.

As a rule the best specimens for a permanent collection are those reared from the caterpillars or gained from

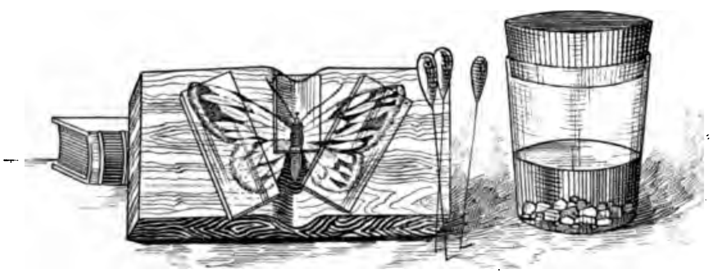


FIG. 223. — Tumbler cyanide jar, wood setting block with glass weights and setting needles. After Denton.

collected cocoons and chrysalides. They can be killed just as soon as the perfect form is attained, before the slightest blemish has come to the wings or body; and surely a collection to have any value must consist of perfect specimens.

The only satisfactory way of killing them is by means of a "cyanide" or poison jar. This can be prepared at any drug store, or by a few minutes' work one can prepare it at home. A large-mouthed bottle with a ground-glass stopper is best; a pint or quart glass fruit jar serves very well indeed; a clear glass tumbler with straight

sides, fitted tightly with a tall cork, will do (Fig. 223). Place at the bottom of the jar a few lumps of cyanide of potash (about two ounces) and cover them with plaster of Paris mixed with water to the consistency of cream. As soon as the plaster sets, the poison bottle is ready for use. Such a jar should be labeled "Poison." It is wise

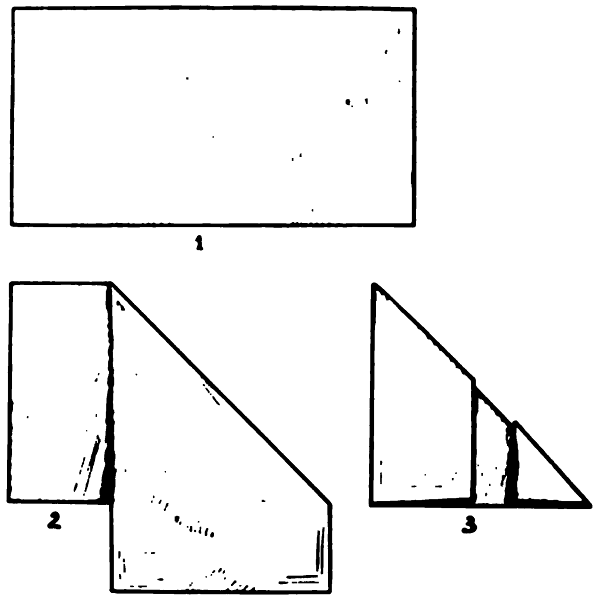


FIG. 224. — Collecting papers. After Denton.

not to breathe the fumes from the cyanide jar. Insects placed in it are killed quickly.

If we are collecting many butterflies or moths at a time, the first two or three must be removed from the poison jar before others are put in, and so on throughout the collecting, in order to keep the specimens perfect. Collecting papers or envelopes are convenient to receive specimens when they are removed from the jar. These

envelopes are made by cutting smooth, strong paper into oblongs, and by folding these oblongs as shown in Fig. 224. Put the moth or butterfly into the envelope head downward, being careful that the wings are folded together smoothly above the back.

The specimens, in their papers, should be exposed to dry summer air for two or three days. In wet weather the papers containing the insects must be exposed to artificial heat. An ordinary stove oven (not too hot and with the door left open) will serve, or a special tin or sheet-iron oven with tall legs can be made and used, as illustrated in Fig. 225.

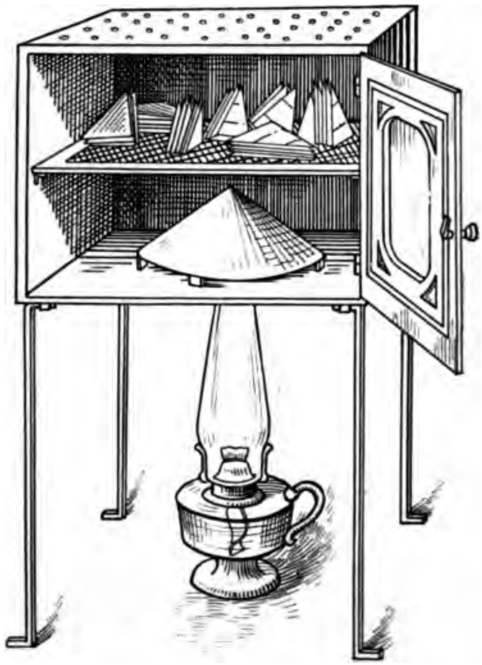


FIG. 225. — Oven for drying insects. After Denton.

The bodies of the large moths are apt to contain a large amount of oil which will ruin the specimens by spreading over the outside of the body and over the wings, unless the abdomen is cut open lengthwise on the underside, the contents removed, and the cavity carefully filled with cotton.

Specimens in folded papers are in convenient shape to be packed away for indefinite keeping or to be sent to friends for exchange.

Before being mounted, specimens must be spread to display the upper surfaces. Spreading is easily accomplished immediately after the removal of an insect from the cyanide jar. If a moth or butterfly has been submitted to a drying process and is afterwards to be mounted, it must be relaxed in some way. Any tightly covered box or dish, with a quantity of wet sawdust at the bottom, will serve for relaxing insects. There should be some contrivance by which the moths and butterflies can be lifted above the sawdust, so as not to be in actual contact with it. A wooden frame with netting stretched over it gives a table to hold them, and yet does not shut out the moisture from them. From twenty-four to forty-eight hours in such a box will soften an insect so that it can be spread easily. A little alum dissolved in the water sprinkled on the sawdust will prevent the formation of mould in the relaxing box.

A smooth pine block should be obtained for spreading moths and butterflies. Pin them through the thorax, back downward, on this pine block.[1] Use finely pointed needles (Fig. 223) to arrange the wings so that the lower margins of the upper wings are at right angles to the body. This position of the wings is not the natural one, but usually displays their form and coloring to the best advantage. Fasten the wings in this position by placing narrow strips of glass over them (Fig. 223). If the moth or butterfly has just been removed from the cyanide jar, it will require several days to dry the specimen for mounting. If it has been dried in a collecting envelope and relaxed, this second drying will require little more than twenty-four hours.

An adjustable setting board like that in Fig. 226 is in common use. This is made of three wooden strips put

[1] Insect pins can be purchased of any one who deals in entomologists' supplies.

together with screws so that there is a groove — as wide or as narrow as required — to receive the body of the moth or butterfly. This groove is usually lined with cork to hold more securely the insect pin put through the thorax of the moth or butterfly. Papers fastened in place with pins or strips of glass can be used to hold the wings in position till they dry.

FIG. 226. — Adjustable setting board for mounting moths and butterflies.

After the specimens are spread and dried they may be pinned in an air-tight box with glass top or in the drawer of a cabinet. They should be placed near related forms and under a label telling their name and the date and locality of their capture. Directions for making boxes and cabinets for insects can be found in Holland's "Butterfly Book" and in many other insect books.

There are many objections to the method of mounting on pins. The specimens are unsightly with pins through them, but, more than that, unless the boxes are absolutely tight, museum pests will find entrance and soon will ruin the collection. Or if the insect box is uncovered, or the drawer of an insect cabinet opened, the insects are so fragile when dry that some one or more is sure to be injured, even by a breath.

The Denton method of mounting in closed glass-covered tablets is by far the better way. Five of these tablets containing butterflies are shown in Fig. 227.

The tablet consists of a plaster mould fitted to receive the body of the butterfly or moth, a pasteboard back, a clear glass cover, and a mucilaged strip of fine white paper to hold these three together after the butterfly is in place.[1]

What are the advantages of this method of mounting? The butterflies are in individual mounts, so that one can be removed from the collection and shown without dis-

FIG. 227. — Butterflies mounted in Denton tablets. Reduced. Photograph.

turbing others. They are thoroughly protected from dust, museum pests, and injury of all sorts for any number of years. The simplest moth or butterfly mounted in this way becomes a most attractive object, with its perfect symmetry set off by a frame of white. Pins and disagreeable odors are avoided in a collection mounted in this way. To be complete the collection should contain two specimens of each sort; one mounted to show the upper side of the butterfly, the other to show the underside.[2]

[1] Send to Denton Brothers, Wellesley, Mass., for their pamphlet, "The Butterfly Hunter's Guide," which tells sizes and prices of the tablets, besides giving full directions for mounting in them.

[2] There is an opportunity for some one to invent a strong, attractive tablet that will have glass above and below to show both sides of a specimen in one mount.

Original Investigation in the Natural History of Moths and Butterflies. — There is perhaps no place in the plant or animal world which presents so broad and delightful a field for discovery along the natural-history line as the world of insects. Of these insects, butterflies and moths, besides being exceedingly common and conspicuous, are the most beautiful members of the group, and so give a good starting point for work. But in addition they give a field where the habits, the life histories, and the simple external structures of some of the most common as well as of the rare members of the group are unknown, so it is in truth a place for original work and for discovery.

Let us begin by finding out in full the life history of one butterfly (the Monarch) or one moth (the Promethea) which is very common in the locality. Let us keep very careful notes on all points with dates of all happenings, so that if we wish to use these facts in any way they will be absolutely truthful, as far as we could make them so.

Our interest will lead us to the study of other forms, and we shall soon know all the moths and butterflies of the place. There usually are no more than forty or fifty common moths and butterflies in one locality, and perhaps never more than one hundred, including all the rare ones. At first the study will consist, as we have said, of detailed observation of one or more forms. Later this study will become comparative; we shall refer new forms or special points in regard to them back to the generalizations that we have naturally made from observation of our first material, and we shall find that we know very many points in regard to the new forms and that we can see even to which of the old forms the new are most nearly related.

In studying any butterfly or moth let us study it in its various stages as a living individual adapted well or poorly for its life in chosen haunts. Let us discover the instinctive habits which serve in protecting it from enemies, and let us look for the fundamental structure that shows life relationship, near or distant, to other creatures.

Some Interesting Moths and Butterflies for Original Study. — Besides the forms whose life histories are given in this book, there are very many common moths and butterflies which will serve as good material for original work for any one interested in the subject.

Use Holland's "Butterfly Book" for identification of the adult butterflies; Comstock's "Manual for the Study of Insects" for identification of the adult moths. Identify the caterpillars by keeping them and studying them until they reach the adult stage. If possible, obtain kodak pictures (or, better still, very carefully focused plates taken with high-grade camera) of the caterpillars whose life histories are studied.[1] Keep the eggs, chrysalides (empty or dead forms), cocoons, and mounted adults together (also the photographs taken), each carefully labeled. Keep also any parasite obtained, with the moth or butterfly on which it is parasitic.

The following are a few of the many interesting forms that may be found and studied.

1. Any member of the group of Skippers. (Refer to p. 248.) Look for the larvæ (Fig. 228) solitary in nests of folded leaves on many kinds of plants, especially on the locust and other plants of the pulse family.

[1] Directions for mounting caterpillar skins can be found in Holland's "Butterfly Book."

2. Any Silver-spot butterfly — large or sometimes medium-sized brown and black butterflies, recognized by the silver spots on the under surface of the hind wings. The Regal Silver-spot, one of the largest of the group, can be found getting the nectar from swamp milkweeds and will be confused at first sight with the Monarch. Look for the spiny larvæ of the Silver-spots, hidden at the bases of violet plants. They feed at night and lie concealed during the day.

FIG. 228. — The larva of a Skipper. Green body; bronze head separated from the body by a neck-like constriction. × 1⅓. Photographed from life.

3. Any one of the Meadow-browns — medium-sized brown butterflies with eye-like spots on the wings. They fly low in most irregular course over meadows, along the edges of woods, and through forest paths. Look for the caterpillars on meadow and roadside grasses; they can be recognized by the pair of short and slender horns at the hind end of the body.

4. The American Copper — the very small orange, black, and bronze butterfly that is exceedingly common through the summer season on clovers, asters, goldenrods, and many small garden flowers. Find the small slug-like larvæ on the common sorrel.

5. The Royal moths are common. Two of the largest caterpillars in the United States are those of the Regal and the Imperial moths. Look for these caterpillars on hickory, butternuts, and other forest trees. They can be recognized by the long spiny horns on the second and third segments.

FIG. 229. — The Rosy Dryocampa moth. Wings pale yellow, banded with rose-color. Resting position. Natural size. Photographed from life.

Other Royal moth larvæ, smaller but having the same spiny horns,[1] can be found on varieties of oak in June and July; and on maple is the green-striped larva of the Rosy Dryocampa. The Rosy Dryocampa is a marvelously beautiful yellow and rose-colored moth (Fig. 229), which can be found resting on stones and fences in the vicinity of soft maples.

6. The Thysbe Clear-wing (Fig. 230). This is a very common reddish brown Sphinx moth, with the central portions of the wings transparent.

FIG. 230. — Thysbe Clear-wing. Reddish brown, with the central portions of the wings transparent. Resting position. × 1¼. Photographed from life.

[1] The Anisota moth larvæ.

Look for the larvæ on snowball and its near relatives in late June and July.

7. There are many other Sphinxes that are common. Among them is the Pen-marked Sphinx. The larvæ (Fig. 231) may be found in June and July on ash, cherry, lilac, and various other trees and shrubs.

FIG. 231.—Young larvæ of the Pen-marked Sphinx. Green, with oblique yellowish white lines. Moulting. Natural size. Photographed from life.

8. Any one of the common hairy larvæ of the Tiger moths, feeding on pigweeds and many other low uncultivated plants, gives good material for original study. These are most interesting during the moulting period.

9. The Evergreen Bagworm. The caterpillar has the curious habit of building a close silken house covered with tiny twigs, in which it lives. It is said that in Ceylon the natives believe that these Bagworms, in some previous existence, were persons who stole kindling wood and are now punished by being made to do the same, as caterpillars. Look on red cedar and arbor vitæ for the Bagworm houses (Fig. 232).

10. On low growths of poplar can be found a curious brown and green Puss-moth caterpillar (Fig. 233). It rests at the middle of the upper surface of the leaf, looking like a part of the midrib. These caterpillars are

most interesting because of the possession of a pair of whiplashes that can be sent out from two horns at the hind end of the [illegible]. These whiplashes [illegible] be curled forward with much force, [illegible] must have effect [illegible] driving away some common flies and other small enemies.

Fig. 232. The Evergreen Bagworm house made of silk, and covered with twigs of cedar. Photographed.

This list could be made endless in extent. Any egg, caterpillar, chrysalis, or cocoon, adult butterfly or moth that is found can be made the starting point for a wonderfully interesting tour of discovery, during which there are sure to come many surprises and many opportunities to marvel.

Fig. 233. — Puss-moth larva. Brown and green. Posterior prolegs replaced by two long horns [illegible] whiplashes which can be thrust out at w[illegible]. Photographed from life.

Some Problems for Investigation. — After becoming acquainted with the habits and life histories of a rather large number

of moths and butterflies, a great many interesting problems for investigation will present themselves to us. The following represent a few of these:

1. What is a caterpillar's method of rolling a leaf to form a nest? Observe the Viceroy, the Red Admiral, any Skipper, or any of the Leaf-rollers. Describe and illustrate.

2. Study the spines on the legs of the Sphinx moths. Illustrate with drawings. Explain the use of these spines for the insect's protection.

3. In a moth or a butterfly the two wings of a side are held together so that they act as one wing during flight. How is this accomplished? Make a comparative study of butterflies, Skippers, Giant Silkworm moths, Sphinxes, Bagworm moths, Slug-caterpillar moths, and any others convenient for study.

4. Find new examples of protective resemblance among moths and butterflies; make kodak pictures or drawings to illustrate moth or butterfly in its protected position.

5. Study the ways in which different caterpillars eat leaves. Illustrate by diagrams, showing leaves in successive stages of being eaten. Compare caterpillars as to the amount of waste of food supply during eating.

6. Study variation in the coloring of caterpillars of a kind.

7. Compare the members of a brood, also different broods of a moth or butterfly, to discover variations in size, coloring, etc.

8. Make a comparative study to find out whether the relationship evident on comparing adult butterflies is plain when comparing their caterpillars and chrysalides.

BOOKS FOR REFERENCE

Comstock's *Manual for the Study of Insects*, Comstock Publishing Company, Ithaca, N.Y. — $3.75.

This is the best book for general use, a book that should be owned by every one interested in the subject of insects. It is adapted for use by young students and by those more advanced.

Holland's *Butterfly Book*, Doubleday & McClure Company, New York. — $3.00.

This is of great value to a person interested in the identification of a large number of the butterflies of North America.

Scudder's *The Life of a Butterfly*, Henry Holt & Co., New York. — $1.00.

Animal Life, by Jordan and Kellogg, D. Appleton & Co., New York.

This book is not limited to moths and butterflies of course, but it contains chapters on primary conditions of life, the struggle for existence, social life, parasitism, protective resemblance and mimicry, adaptations, instinct, etc., which should be carefully read by any one interested in any form of animal life.

Gibson's *Sharp Eyes*, *Eye Spy*, and *My Studio Neighbors*, Harper & Brothers.

These are "inspiration books."

Write to State Agricultural Experiment Stations for lists of bulletins. These bulletins are distributed free of charge.

Get lists of bulletins issued by the Departments of Agriculture and Entomology at Washington, D.C. The majority of these are for free distribution.

Everyday Butterflies. Scudder.

Frail Children of the Air. Scudder.

Butterflies. Scudder. (This deals with problems of ancestry, distribution, etc.)

Insect Life. Comstock.

Insects and Insecticides. Weed.

Butterflies of the Eastern United States. French.

Moths and Butterflies of the United States. Denton. (Very expensive.)

Insects Injurious to Vegetation. Harris.

Insects. Hyatt and Arms.

GLOSSARY

Abdomen (ab-do′men): the hindermost of the three main divisions of an insect's body.

Alimentary canal (al-i-men′ta-ry ca-nal′): that passage in an animal's body that receives and digests the food.

Ancestry (an′ces-try): the preceding generations of an animal.

Antenna (an-ten′na), p. 8.

Anterior (an-te′ri-or): situated in front, *i.e.*, nearer the head.

Cephalothorax (ceph-a-lo-tho′rax), p. 278.

Chitin (ki′tin), p. 22.

Chrysalis (krys′a-lis): the immature moth or butterfly in the inactive condition that follows the larva and precedes the perfect form; pupa.

Cocoon (co-coon′): a covering of silk spun by a caterpillar as a protection for the inactive chrysalis.

Cremaster (cre-mas′ter), p. 27.

Cross-pollination (cross-pol-li-na′tion): the transfer of pollen from one flower to another through the agency of insects or the wind.

Dimorphism (di-mor′phism), p. 265.

Double-brooded (dou′ble-brood′ed): the completing of the life history of any species, *i.e.*, passing from egg to the perfect moth or butterfly, twice in one year.

Entomology (en-to-mol′o-gy): the study of insects.

Environment (en-vi′ron-ment): the surroundings, taken collectively, of any plant or animal.

Facets (fac′ets): small surfaces of symmetrical form, as the triangular surfaces of a diamond; the units of a compound eye.

Heredity (he-red′i-ty): the carrying of animal structures and instincts from one generation to another.

Hibernation (hi-ber-na′tion): passing the winter in a profound sleep in some secluded place.

Insectivorous (in-sec-tiv′o-rous): feeding upon insects.

Instinct (in′stinct): a natural impulse, not the result of reason, to perform the acts necessary for the existence not only of the individual but also of the race. Instincts are hereditary.

Intelligence (in-tel′li-gence): as used in this book, capacity to reason; opposed to instinct, which performs acts without reasoning in regard to them.

Invertebrate (in-ver'te-brate): lacking an inner skeleton of bone.

Larva (lar'va): the worm-like stage in the development of an insect, following the egg and preceding the pupa. The larva of a moth or butterfly is called a caterpillar.

Life History: the story of the development of an animal from the egg to the adult.

Mandibles (man'di-bles), p. 19.

Metamorphosis (met-a-mor'pho-sis): the marked changes of form and structure through which an insect passes in its development from the egg. The various stages in the metamorphosis are known as larva (the caterpillar of moths and butterflies), pupa (the chrysalis of moths and butterflies), and adult or imago.

Migration (mi-gra'tion): passing from one part of the country to another, especially in large companies.

Mimicry (mim'ic-ry), p. 263.

Moulting (moult'ing): among insects, casting or shedding the outside skin.

Natural Selection (nat'u-ral se-lec'tion): the process by which individual variations of advantage to an animal in a certain environment become perpetuated in the race. See pp. 261–264.

Nauseous (nau'seous): loathsome to the taste.

Osmateria (os-ma-te'ri-a), p. 40.

Parasite (par'a-site): a plant or animal that lives upon or within another plant or animal, from which it derives its nourishment.

Polymorphism (pol-y-mor'phism), p. 265.

Posterior (pos-te'ri-or): situated toward the hinder part, *i.e.*, farthest from the head; opposed to anterior.

Proboscis (pro-bos'cis), pp. 12, 31.

Prolegs (pro'legs), p. 17.

Protective Resemblance (pro-tect'ive re-sem'blance), p. 262.

Pupa (pu'pa): that stage in the development of an insect preceding the perfect form; the pupa may be active as in the grasshopper, or inactive as in the moth or butterfly.

Segmentation (seg-men-ta'tion): division of an animal's body into a series of more or less similar rings or segments.

Single-brooded (sin'gle-brood'ed): the passing of any species from the egg stage to the perfect form but once each year.

Specialization (spe-cial-i-za'tion): the change that takes place in the parts of an animal making them different from their simple condition in the typical animals of the group, in order the better to fit the part for its work and the animal for its life.

Spinneret (spin'ner-et), Fig. 11, p. 18.

Spiracles (spir'a-cles), p. 19.

Thorax (tho′rax): the middle region of an insect's body between the head and the abdomen. An insect's thorax consists of three segments and bears the legs and wings.

Tracheæ (tra′che-æ), p. 20.

Tubercles (tu′ber-cles): small knob-like projections common on caterpillars.

Variation (va-ri-a′tion): change in form, color, structure, or habit from the condition in the type or parent, usually in response to demands of the environment.

Vertebrate (ver′te-brate): having an inner skeleton of bone.

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